THE OHIO JOURNAL OF SCIENCE

VOL. XLII SEPTEMBER, 1942 No. 5

BOTTOM ANIMAL COMMUNITIES OF THE ISLAND AREA OF WESTERN LAKE ERIE IN THE SUMMER OF 1937[1]

V. E. SHELFORD,
University of Illinois,

and

M. W. BOESEL,
Miami University

The resemblance between the communities of different stream stages and those of large lakes has been mentioned frequently (Shelford, 1913) but rarely analyzed. The presence of swift-water animals on wave-beaten shores has been noted by Krecker (1924). Shelford (1913) and Clements and Shelford (1939) took account of the climaxes of large lakes and rivers. The area of study is located about the islands in western Lake Erie immediately north of Sandusky Bay. The waters studied lie within an area 11.50 x 14.35 miles (18.5 x 23.0 kilometers). The water is shallow; more than half of it is less than 30 feet (9.14 M.) and approximately one-fourth is less than 21 feet (6.4 M.) in depth. The greatest depth, located at a point north of Kelleys Island, is 52 feet (15.85 M.). The depression at this point includes three or four square miles with a depth of more than 43 feet (13.1 M.). There are three other shallower pockets northwest and southwest of South Bass Island. (Figs. 1 and 2.)

Strong currents sweep between the islands during storms. There is evidently a moderate current around the south end of Pelee Island at all times, as indicated by the bottom, which is consistently sand. In winter, ice has an important abrasive effect on local bottom conditions and is especially noticeable along the rock and boulder ridge which extends west from Kelleys Island.

The study here reported laid primary emphasis on the bottom communities of the lake proper. In shallow water down to 3.35 feet (0–1 M.) quantitative studies were made through observations made directly on the bottom or from rocks picked up by hand or with tongs. However, bottom samples taken principally with the Petersen bottom sampler formed the basis of most of the work.

The bottom sampler work was supplemented with collections made by the Ekman sampler, a triangular dredge, a Helgoland trawl, a large multiple meshed tow net, a detritus sampler, and the CoVan dredge, which was designed by Mr. CoVan, Ohio State University. It consisted of a flat triangular frame or plate with three draw rods (for attachment of a rope) rigidly fastened upright in the corners; the center of the frame or plate was an opening to which a sack was attached. When weighted at the bottom of the draw rods, this had the advantage of digging into the bottom while drawn at a sharp angle in the water. (Fig. 3.)

Dredge samples were purely qualitative. The Helgoland trawl and a large tow net with several mesh sizes were not effective in securing young fishes.

[1]Contribution from the Franz Theodore Stone Laboratory of Ohio State University, from the Zoological Laboratories of the University of Illinois and from the Department of Zoology of Miami University.

The detritus sampler used to determine the amount of detritus consisted of a lead weight in which a glass tube was inserted. This was dropped to the bottom, forced into the mud, and, in cases of very fine materials, could be brought to the surface of the water with a good sample of the detritus at the surface of the mud

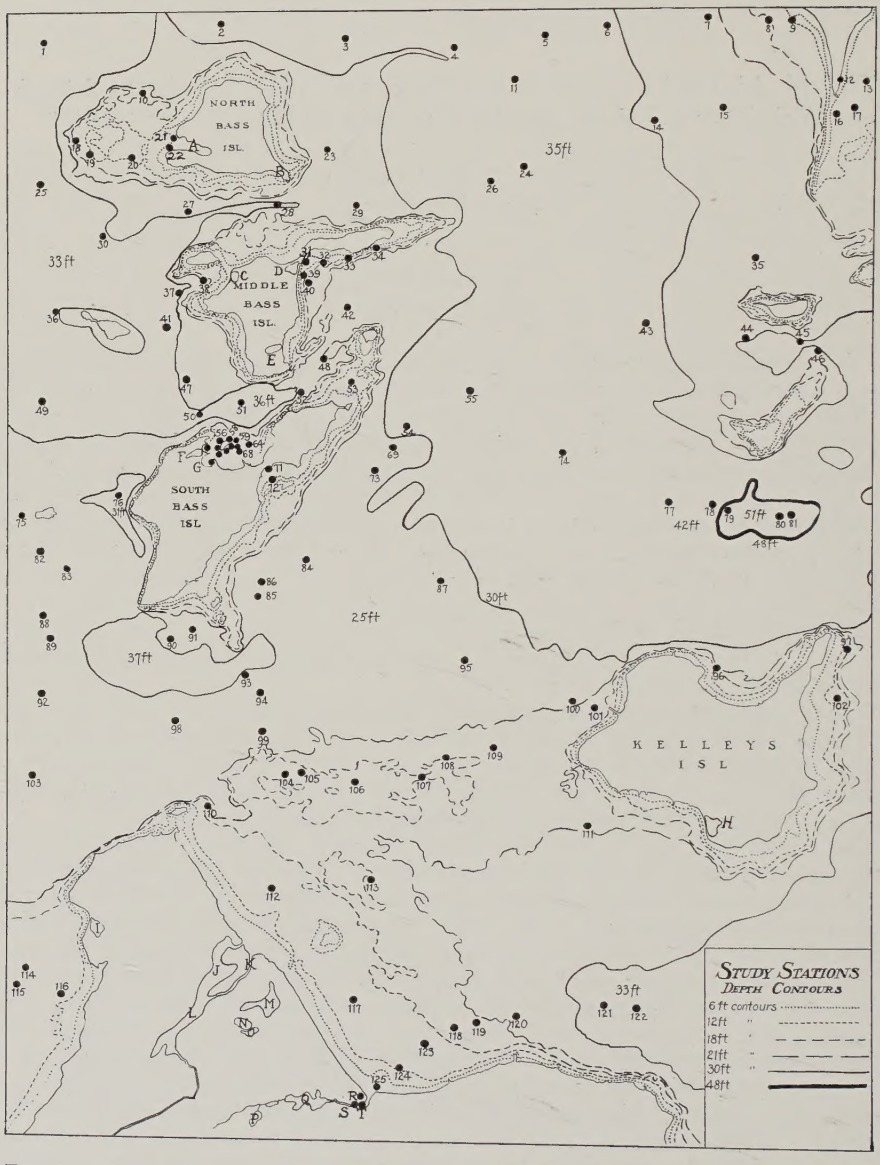


FIG. 1. Map of the area of study with depth contours and the location of stations.

as well as the mud itself. The plankton, which contributes to the detritus, has been studied by others, but no work was done in this connection by the writers.

No attempt to evaluate the stages of succession to land was made. The senior author made extensive studies of these stages at the south end of Lake

Michigan from 1906 to 1912 (Shelford, 1911b, 1911c, 1913). Western Lake Erie conditions are similar, but are characterized by a probably greater abundance of animals, a more open connection with the lake, and a confused arrangement of stages. The last condition makes a prolonged study necessary to advance the knowledge of succession greatly.

FIG. 2. The details of depth and stations about the Stone Laboratory not shown in Figure 1.

COMMUNITIES

In streams two main types of communities have been recognized, which may be provisionally identified by their habitat characteristics, viz., (a) turbulent-water, hard-bottom communities and (b) still-water, mud-bottom communities. There are also communities less distinct and usually intermediate in character (Shelford and Eddy, 1929). Climax aquatic communities are partially controlled by animals, and the habitats dominated by vegetation are usually stages of succession to land. (Fig. 4.)

In dealing with the communities in the area of study, the general subdivisions were found to apply. The still-water, mud-bottom communities will be considered last, and the turbulent-water, hard-bottom communities will be presented first.

THE GONIOBASIS-HYDROPSYCHE COMMUNITY.

According to the conclusions derived from the study of streams (Shelford in Clements and Shelford, 1939), attention is brought to the communities of turbulent waters, which stand out in contrast to those of the still water as described below.

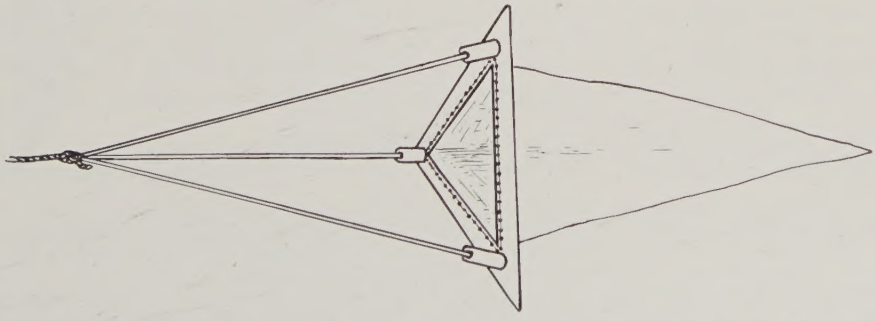


FIG. 3. The CoVan dredge. When heavily weighted it can be drawn at a sharp angle. It then only scrapes the surface and does not fill with mud quickly.

The studies of the Goniobasis-Hydropsyche community were made in an intensive manner about Gibraltar Island and at two stations where the sampler brought up efficient samples of small boulders, whose exposed surface area could be measured, as well as some good samples of gravel. List I shows the animals taken from 10 M². A study of occurrence of *Goniobasis* by Krecker (1924) indicated that it is most abundant in the early stages of succession to land, i. e., protected places swept clear by currents produced by oscillations in lake level. *Goniobasis* or *Hydropsyche* appeared in all of the collection stations where quantitative work could be done and the two were accordingly chosen to designate the community. In shallow water, water-penny larvae (*Psephenus lecontei*) were more often present than either of the other two. They did not appear in the deeper water, however. The area between depths of 6 and 8 meters does not have several of the species. Eight meters is approximately the depth limit of wave motion sufficient to move fine sand or coarse silt. This amount of water movement is often deeper when produced by currents and the depth to which boulders will be swept clean varies with general physiographic conditions. The lower limits of this may be expected to vary likewise.

LIST I

A collection of invertebrates from 10 M² of bottom in the Goniobasis-Hydropsyche community, western Lake Erie, July and August, 1937; 0–25 feet (0–8 M.) depths.

*1. *Cricotopus exilis* Joh., *et al.*, Midge larva.....Est. 10,000
*2. *Hydropsyche sp.* Caddice-fly larva....703
3. Bryozoan colonies.....317
*4. *Stenelmis crenata* Say, *et al.* Parnid beetle and larva.....170
*5. *Stenonema tripunctatum* Banks and *S. pulchellum* Walsh. Flat mayfly nymphs.....152
*6. *Physa sp.* Snail.....128
*7. *Goniobasis livescens* Menke. Snail.....121
*8. *Psephenus lecontei* (Lec.). Water-penny.....72
9. Sponge colonies.....27
10. *Planorbula crissilabris* Walk. Snail...21
11. Leptoceridae. Caddice-fly larva.....16
12. *Glossiphonia sp., et al.* Leech.....15
13. *Amnicola limosa porata.* Snail.....3
14. *Helicopsyche sp.* Caddice-fly larva....2
15. *Cheumatopsyche sp.* Caddis-fly larva..2
16. *Baetis sp.* Mayfly nymph.....2
17. *Pentaneura sp.* b. Midge larva.....2
18. *Stenonema interpunctatum* Say. Flat mayfly.....2
19. *Molanna sp.* Caddice-fly larva.....1
20. *Centroptilum* sp. Mayfly nymph.....1
21. *Planaria* sp.....1
22. *Argia moesta* Hag. Swift-water damsel-fly nymph.....1
23. *Amblema costata* Raf. Mussel.....1
24. *Leptodea fragilis* Raf. Mussel.....1
25. *Lampsilis siliquoidea rosacea* DeKay. Mussel.....1
26. *Elliptio dilatatus sterkii* Grier. Mussel..1
27. *Chironomus sp.* p. Midge larva.....1
28. *Chironomus pallidus* Joh. Midge larva.....1
29. *Chironomus sp.* Midge larva.....1

The collections from which List I was arranged were made at stations 21 (½ M², depth 2 M.), 32 (½ M², depth 5 M.), 57, 58, 59, 62, 63, 64 (0.6 M², depth 6 M.), 65 a, 65 b, 65 c, 65 d (1 M², depth 2 M.). The stations for which depths are not given ranged from 0–1 M. *Cricotopus exilis*, the web-forming midge, ranged from 0–1 M. The other motile species decreased in abundance with depth. Thus the results are only roughly quantitative. The observations were carried out as follows: In depths 0–1 M., ten 0.1 M² areas were marked off and all animals were counted as observed on and under stones and elsewhere. In depths greater than 1 M., the Petersen bottom sampler was used to pick up coarse gravel and small boulders and the exposed surfaces of these measured; all animals remaining attached to them were counted

*The asterisk before items 1, 2, 4, 5, 6, 7, and 8 indicates that the quantitative data are for stations of 0–1 M. depth. The following comments refer to the corresponding numbers in the list.

(1) *Tanytarsus exiguus* Joh. was also reared, but all specimens identified were from under stones or the deeper water. (2) *Hydropsyche*, (7) *Goniobasis livescens*, and (8) *Psephenus lecontei* were not taken below 18 feet (5½ M.). (4) *Stenelmis vittipennis* Zim. appeared in one collection. One individual is included in the 170 listed as *S. crenata*. A few others may have occurred. (5) The proportions of these two species were not determined, but the populations appear about equally divided between the two. A few *Stenonema interpunctatum* appeared in the deeper water. (6) A few *Pleurocera* were found in two stations (total, 4 specimens from 1.0 M²).

and added to those brought up loose in the sampler. 1 M² was estimated to have been covered in terms of rock surface. Between 10 and 15 M² at a depth of 2–8 M. were picked over with the sampler or scraped with the dredges. This work covered stations 10, 20, 36, 39, 52, 53, 71,

FIG. 4. Provisional map of the bottom communities. The community conditions between stations were inferred from the depth and what is known of currents and circulation.

75, 89, 94. 98, 107, 108, 114 and a few others, all on a qualitative basis. The qualitative results were of value in that they showed nearly all the species present. Heptageninae, numerous in shallow water, were not taken in the deep samples. These flat mayfly nymphs may readily wash off the stones picked up with tongs or the sampler.

The fishes listed were collected over station 65, rock and gravel bottom, depth 0–1.5 M.

1. Log-perch—*Percina caprodes* (Raf.)
2. River darter—*Cottogaster copelandi* (Jordan)
3. Yellow perch—*Perca flavescens* (Mitch.)
4. Blunt-nosed minnow—*Hyborhynchus notatus* (Raf.)
5. Steel-colored shiner—*Notropis spilopterus* (Cope)
6. Northern mimic shiner—*Notropis volucellus volucellus* (Cope)
7. Large-mouthed bass, 1 inch long—*Huro salmoides* (Lac.)

The following fishes are also noted as common in such localities by Turner (1920).

1. Yellow perch—*Perca flavescens* (Mitch.)
2. Log-perch—*Percina caprodes* (Raf.)
3. River darter—*Cottogaster copelandi* (Jordan)
4. Small-mouthed bass—*Micropterus dolomieu* Lac.
5. Spot-tailed minnow—*Notropis hudsonius* (Clinton)
6. Large-mouthed bass—*Huro salmoides* (Lac.)
7. Brook silverside—*Labidesthes sicculus* (Cope)

The Pleurocera-Lampsilis Community.

Intermediate between the Goniobasis-Hydropsyche and mud bottom (Hexagenia-Oecetis) communities is the Pleurocera-Lampsilis community. This is characteristic of sandy bottoms which are usually shifting. This community is not so extensive as the Hexagenia-Oecetis community or so accessible as the Goniobasis-Hydropsyche community. Bottom sampling is more difficult on account of the coarse-meshed sieves which must be used, while dredging, on the other hand, is easy. Five M^2 were sampled with the Petersen sampler and a relatively large area dredged over. This is estimated as at least 15 M^2. Twenty-nine species are listed below as representing twice the population of 5 M^2 as taken with the Petersen sampler. *Pleurocera acuta* and *Lampsilis siliquoidea rosacea* are the two most abundant and uniformly distributed species. Three other mussels are quite generally present. *Goniobasis* occurred in only 3 out of 65 Petersen samples and 1 of 15 dredge hauls. The chironomids and other insect larvae and adult corixids were scattered, usually as single individuals at a station.

LIST II

Twice the actual collection from 5 M^2 (an estimate for 10 M^2) of bottom in the Pleurocera-Lampsilis community of western Lake Erie, July and August, 1937.

1. *Pleurocera acuta* Raf. Snail.....66
2. *Lampsilis siliquoidea rosacea* DeKay. Mussel.....16
3. *Obovaria subrotunda* Raf. Mussel.....12
4. *Leptodea fragilis* (Raf.). Mussel.....10
5. *Fusconaia flava parvula* Grier. Mussel.. 8
6. *Goniobasis livescens* Menke. Snail..... 8
7. *Chironomus sp.* d..... 8
8. Leptoceridae. Caddice larva..... 6
9. *Chironomus digitatus* Malloch. Midge larva..... 6
10. *Lampsilis ventricosa* Barnes. Mussel... 4
11. *Hexagenia sp.* Mayfly nymph..... 4
12. *Ephemera sp.* Mayfly nymph..... 4
13. *Sialis sp.* Larva..... 4
14. *Procladius culiciformis* Linné. Midge larva..... 4
15. *Chironomus sp.* l. Midge larva..... 4
16. *Chironomus sp.* b. Midge larva..... 4
17. *Chironomus sp.* g. Midge larva..... 4
18. *Gammarus limnaeus* (Smith). Amphipod. 4
19. *Chironomus flavus* Joh. Midge larva.... 2
20. *Arctocorixa lineata* Forster..... 2
21. *Limnephilus sp.* Caddice larva..... 2
22. *Stenelmis bicarinatus.* Parnid larva..... 2
23. *Stenelmis crenata* Say. Parnid larva.... 2
24. *Birgella subglobosa*..... 2
25. *Micromyza fabulus*..... 2
26. *Elliptio dilatatus sterkii* Grier..... 2
27. *Chironomus sp.* k..... 2
28. Bryozoan colonies..... 2
29. *Planaria*..... 1

The status of this community is similar to that of the sandy bottoms of streams: after storms the sand is shifted, removing most of the animals and leaving areas of denuded sand, which is invaded by the species most abundant in nearby areas and a sparse population is built up, only to be washed away again. Thus areas of barren sand are common in the territory occupied by the community. Fishes frequenting these areas were not collected.

The Hexagenia-Oecetis Community.

The community of greatest significance from the standpoint of the fisheries of the area is the one occupying the still-water, mud-bottom areas and characterized by many mayfly nymphs of the genus *Hexagenia*, many chironomid larvae, and characteristic caddice-fly larvae.

LIST III

AN AVERAGE COLLECTION OF INVERTEBRATES FROM 10 M² OF BOTTOM IN THE HEXAGENIA-OECETIS COMMUNITY, JULY AND AUGUST, 1937

1. *Hexagenia occulata* Walk. Burrowing mayfly nymph.....186
2. *Hexagenia rigida* McD. Burrowing mayfly nymph.....142
3. *Chironomus digitatus* Malloch. Midge larva..... 63
4. *Coelotanypus scapularis* Loew..... 42
5. *Limnodrilus*. Aquatic earthworms.... 32
6. *Procladius culiciformis* Linn. Midge larva..... 29
7. *Oecetis inconspicua* Walker. Caddice-fly larva..... 27
8. *Chironomus curtilamellatus* Malloch. Midge larva..... 22
9. *Chironomus*, several unidentified species..... 12
10. *Pentaneura monilis* Linn. Midge larva. 9
11. *Chironomus decorus* Johannsen. Midge larva..... 8
12. *Valvata tricarinata* Say. Snail..... 6
13. *Lampsilis siliquoidea rosacea* DeKay. Mussel..... 6
14. *Herpobdella punctata* (Leidy). Leech.. 6
15. *Fusconaia flava parvula* Grier. Mussel. 4
16. *Gammarus fasciatus* Say. Crustacean.. 3*
17. *Pisidium sp.* Bivalve..... 3
18. *Glossiphonia stagnalis* (L.). Leech..... 3
19. *Pleurocera acuta* Raf..... 2
20. *Cricotopus trifasciatus* Panzer. Midge larva..... 1
21. *Goniobasis livescens* (Menke.). Snail... 1
22. *Protera alata* (Say). Mussel..... 1
23. *Ligumia nasuta* (Say). Mussel..... 1
24. *Trunciila donaciformis* (Lea). Mussel. 1
25. *Cambarus argillicola*. Faxon. Crayfish. 1
26. *Amblema costata* Raf. Mussel..... 1
27. *Lunnesia undulata* (Müll.). Mite..... 1
28. *Arctocorixa lineata* (Forst). Water-boatman..... 1*
29. *Gammarus limnaeus* (Smith). Amphipod 1*

*Figures not quantitative, catch merely incidental.

The abundant fishes associated with the invertebrates enumerated and related to the bottom in their feeding and breeding relations are northern brown bullhead (*Ameiurus nebulosus nebulosus* (Le Sueur)), sheepshead (*Aplodinotus grunniens* Raf.), eastern white sucker (*Catostomus commersonnii commersonnii* (Lac.)), and the European carp (*Cyprinus carpio* Linné). To what extent these species control their habitats by destroying vegetation is not clear. Characeae are recorded as abundant from Lake St. Clair (Pieters, 1894) and very rare in Lake Michigan (Shelford, 1913, p. 74). A number of largely piscivorous fish such as the yellow pike-perch (*Stizostedion vitreum vitreum* (Mitch.)), blue pike-perch (*S. vitreum glaucum* Hubbs), eastern sauger (*S. canadense canadense* (Smith)), yellow perch (*Perca flavescens* (Mitch.)) also occur.

The life histories of the constituents enumerated above are known only for a few species. It is evident, however, that *Hexagenia* is perennially present, since in late summer young nymphs are found as well as late-emerging individuals. The caddice-fly larva *Oecetis inconspicua* Walker, appears to be a fair indicator of the community. It appears that their cases will usually be present until the larvae of the next generation become recognizable. Unfortunately, few of these were carried to the adult stage.

Out of 35 stations yielding *Hexagenia* nymphs, 17 yielded larvae of *Chirinomus digitatus* and 14 yielded larvae of *Coelotanypus scapularis*. Both midge larvae were present in only five or six stations, a fact not easily correlated with physical conditions.

The list of species present shows only 8 abundant enough so that one or two individuals may be expected in any square meter sample. Of the Mollusca *Valvata tricarinata*, *Lampsilis siliquoidea rosacea*, and *Fusconaia flava parvula* are the only ones likely to be found on two square meters. The swimming habits of the amphipods make their occurrence in collections problematical and incidental.

DETRITUS AND MICROSCOPIC FORMS OF THE BOTTOM

The surface of the bottom is covered with a layer of flocculent detritus consisting of about 90% to 95% debris from higher plants, mixed with plankton detritus. The remains of the following organisms were noted; comparison with the plankton indicates that the list is far from complete.

1. Phytoplankton detritus: (a) Diatoms: *Diatoma, Gomphonema, Melosira, Cyclotella, Stephanodiscus, Closterium, Synedra, Fragilaria, Meridion, Campylodiscus, Staurastrum;* (b) Blue-green algae: *Anabena, Oscillatoria;* (c) Filamentous algae: *Tribonema, Spirogyra, Zygnema.*

2. Zooplankton: copepod debris, cladoceran debris, other crustacean debris, *Triarthra* (rotifer), *Difflugia* and *Arcella* (Protozoans). 3. Living forms: *Chaetonotus brevispinosus* (Gastrotricha), *Mesostoma*, (flatworm).

The presence of so much higher plant debris obscures the brown layer resulting from plankton detritus, especially diatoms, readily seen in most bodies of still water, particularly in late summer. Mixed with the debris are small particles of silt, which have the appearance of translucent nodules when viewed under the microscope. The flocculent debris decreases and silt particles increase with depth. The top one or two millimeters are usually without an appreciable number of sand grains. The amount of sand increases with depth, but there is not much other change through the top four or five centimeters. Below this point the material is more closely consolidated but still with much plant debris to a depth of 10 or 12 cm. Separation of the particles in some 12 cm. samples shows the detritus to make up nearly half of the amount.

After severe storms the yellowish green detritus colors the water in harmony with its own color and several days are required for the water to clear.

To determine the per cent volume of the detritus, 6 samples to a depth of approximately 6 cm. and 6 samples to a depth of 3 cm. were sent to the Ohio Agricultural Experiment Station, where the work was done by courtesy of Dr. G. W. Conrey.

LIST IV

SHRINKAGE OF LAKE ERIE MUD SAMPLES ON FIRING

Station	Depth in mm.	Shrinkage Percent	Station	Depth in mm.	Shrinkage Percent
80	60	59.5	81	29	51.0
77	60	58.0	55	31	57.0
42	60	51.5	83	30	55.0
77	61	57.0	24	29	56.5
30	59	62.0	29	30	34.0
2	60	62.2	43	33	50.0

Depth refers to the distance from the bottom surface to the bottom of the sample in the tube. The shrinkage was increased to between 102 and 103 per cent of the original figures to account for an assumed 2 or 3 per cent of ash in the plant debris. The shrinkage is least where there is current flow between islands and where water is deepest.

RELATION OF DETRITUS TO THE ANIMAL ORGANISMS OF LAKE ERIE

(1) ORIGIN OF DETRITUS.

Some of the detritus material may wash in from the land, but the aquatic plants growing in the lake and lagoons, and ponds connected with it are the principal sources. The fresh-water eel-grass and tape-grass (*Vallisneria spiralis* L.) is probably the principal source. There are large areas of this, which occur about the islands in the area of study.

(2) RELATION OF THE LARGER INVERTEBRATES TO THE DETRITUS.

The stomach contents of *Hexagenia occulata* were studied. Specimens were taken from Station 42 and examined immediately. The contents of two typical specimens are enumerated.

I.

a. Higher plant tissue (detritus).

b. Filamentous algae.

c. Diatom shells.

d. Sand grains in greater proportion than in detritus, indicating some digestion.

II.

a. Higher plant detritus.
b. *Diatoma* shells 3
c. *Tribonema* shells 1
d. *Synedra* shells 1
e. Entomostracan parts 3
f. Copepod parts 2
g. *Triarthra* parts 1
h. Cladoceran parts 2

(3) Relations of the Vertebrates to the Detritus-Eating Invertebrates.

The stomachs of several of the associated fishes were examined, but in most cases they had been in the trap so long that their stomachs were empty. The bottom feeders are not likely to avoid eating detritus directly, as much of their animal food is embedded in it.

The stomach contents of a sheepshead examined very soon after its capture showed:

Hexagenia, nymphs	4	*Limnodrilus*	1
Leech	1	Chironomids	10

The chironomids were identified as *Chironomus sp.* b (not reared) taken only at stations 21, 22, 36, 72, and *Chironomus digitatus*, which was widely distributed.

The presence of these in the stomach of the fish establishes a food chain in which the principal ultimate source of nourishment is the tissues of some of the higher plants.

DISCUSSION

Two lines of thought present themselves for elaboration. (a) One is essentially a comparison of the findings in western Lake Erie with those of Petersen and his associates in the marine waters about Denmark and, (b) the other is a comparison of the three communities described and a consideration of the general system of classification of communities in fresh waters.

1. Fisheries Problems.

The outstanding work of the Danish Biological Station has attracted attention. The resemblance between the marine condition about Denmark and the west end of Lake Erie justifies a comparison with Danish findings. In the Danish waters, the principal features of the system of aquatic life are the following:

1. The bottom invertebrates make up the principal source of food of many of the commercial food fishes.
2. The invertebrates feed largely on detritus.
3. The chief source of detritus is eel-grass.
4. Eel-grass affords protection to the young of food fishes while they are small.

The conditions found in western Lake Erie appear almost parallel to those in the Danish waters as regards a large group of fishes. The extent to which plants that form the detritus also serve as shelter of small fry is evident in some cases, in general terms only.

There are large areas of fresh-water eel-grass or ribbon-grass (*Vallisneria spiralis*) and some other aquatic plants which doubtless contribute to the detritus. The beds occur in shallow water usually partially protected. The dense vegetation of the shallow bays and marshes connected with the lake contributes much. The manner in which the plant fragments are swept out of the bays and lagoons, where plants grow in profusion, is brought out by Krecker (1931) in his study of vertical oscillations in the same area studied by the writers. The inflow and outflow of water in lagoons is sufficient to leave some channels free of vegetation. The writers conclude that this indicates a current sufficient to carry plant fragments into the lake proper. Krecker refers to the importance of these open channels in that "they afford indispensable feeding and breeding grounds to thousands of fishes." To what extent the bottom feeders of the lake proper are involved has not been properly studied.

The importance of the mayflies and detritus, including that from the lagoons, to the commercial fisheries of western Lake Erie can hardly be doubted.

The Goniobasis-Hydropsyche community is evidently of considerable importance to the small and young fishes which supply food to piscivorous species. The Mollusca, no doubt, play an important role (Baker, 1916). The Pleurocera community is evidently of less importance than the Goniobasis community.

2. Comparison and Classification of Communities.

The bottom invertebrates and bottom-frequenting fish, together with the plankton and such pelagic fishes as may occur, constitute one biotic unit. The writers believe this to be the best grouping even in lakes as large as Lake Erie.

There is evidence from rivers that fishes are among the most important constituents of aquatic communities. The extensive control of substratum and vegetation by which fishes tend to maintain conditions suitable for themselves (Cahn, 1929; Ricker, 1932) can hardly occur on an important scale in waters in which rooted vegetation is unable to grow. Still the three main community types found in streams, namely, (a) swift water communities, usually on hard coarse bottoms, (b) communities on shifting bottoms—usually sand in water with moderate currents, and (c) communities in still water usually with mud bottoms, are all quite evident. Thus the three communities of which 29 constituent species are named for each in Lists I, II, and III, conform to the three types described for streams (Shelford, 1913, pp. 93–105). Shelford and Eddy (1929) did not mention the sand-bottomed habitats; Clements and Shelford (1939) followed the same plan. This results from the fact that the sand-bottom community is not usually very distinct in streams. Gersbacher (1937), however, recognized it as a definite but short-lived community.

In western Lake Erie it is a distinct community, as may be seen from a comparison of Lists I, II, and III. The three lists may also be compared with Gersbacher's Musculium-Lampsilis community. Gersbacher regarded this as a fraction of the Hexagenia community. However, according to the observations of the senior author, this does not apply to sand-bottom communities in some other streams.

SUMMARY OF CONCLUSIONS

The classification of aquatic communities has been carried out chiefly from two viewpoints.

1. The habitat, kind of bottom, *etc.*, have been used as a basis for expressing the occurrences of the animals. They are referred to as occurring on sand, on mud, *etc.* Groupings characteristic of certain conditions are recognized by Pearse (1939, Chapter 9).

2. The most abundant animals are considered as indicators of the usual presence of other less abundant ones, while all the life is regarded as constituting a community. This viewpoint has two propositions as its background, namely, (a) that there are important relations between the species concerned, and that they have important reactions on the habitat, (b) that in areas denuded of life, animals and plants appear in succession as the organisms change the character of the habitat. The occurrence of a climax stage is supported by some good evidence (Gersbacher, 1937).

Those who use interactions, succession, and climax as a basis for the classification of communities put the aggregations of organisms ahead of the physical conditions due to (1) a partial control by the organisms and (2) the fact that the physical conditions as commonly interpreted are often confusing. A given kind of bottom does not necessarily have the same community upon it under the same conditions of depth, temperature, etc., because circulation of the water medium appears to be more important than the bottom. From the point of view of this investigation, a community is regarded as being controlled by the more potent and abundant species, and the same community occurs wherever the principal organisms are the same. In some cases, a part of these organisms is the same, and a part is different. On land, at least, this is the basis for separating the large primary communities called *biomes* from the smaller subdivisions called associa-

tions. Wherever there is a complete change in all the important species, a new biome (major community) is regarded as occurring.

As to the degree of control by fishes in Lake Erie, we have no evidence. Lake St. Clair, however, is covered (Pieters, 1894) to its greatest depth (7 meters) with Characeae, wherever alluvium occurs. There appears to be no good aquaclimatic reason for their absence in Lake Erie. Cahn (1929) and Ricker (1932) and unpublished work of the Illinois Natural History Survey have indicated the potency of fishes in removing vegetation. We have unfortunately no qualitative knowledge of the fishes of Lake St. Clair. Qualitatively, the majority of the fishes known to influence bottom vegetation (dominants) are known to occur only in the tributary streams (Ms. list by C. L. Hubbs). This suggests the importance of careful study of the influence of fishes on their habitats and the associated plants in the large lakes. At least, it is evident that in the areas of study, the combination of the present hydroclimate and fish population will tend to make the communities what they are today for an indefinite period.

The Hexagenia-Oecetis[2] community type is the only one which may be regarded as permanent, stable, and probably climax in both streams and large lakes. At the same time, the other two communities described cannot be regarded as a part of a sere, or biotic succession, which are seral only in a broad physiographic sense. These communities will be succeeded by the climax Hexagenia type only after millions of years of erosion and rock disintegration, in which organisms play a part. This puts their change to the climax type in a category in no wise comparable with the development of a climax in 10 or 15 years or less, as described by Gersbacher (1937). Any attempt to discuss these two communities as seral stages only leads to confusion.

The sand-bottom community appears to the writers as comparable to moving sand on land, which is never stabilized. That on the lower beach of the Great Lakes is an example. The community on rock and boulder areas appears to be like the more stable rock and talus areas on land. These are too steep and jagged and exposed for plants to cover them and hence any approach to the climax of the area would call for millions of years of rock disintegration and erosion.

ACKNOWLEDGMENTS

The writers are indebted to Dr. D. M. DeLong, Director of the Franz Theodore Stone Laboratory in 1937, for his support of the work, and to Dr. T. H.Langlois for the loan of equipment. Their sincere thanks is due the following for the identification of specimens of the various invertebrate groups not covered by the junior author: F. C. Baker, Mollusca; Jay R. Traver, Mayfly nymphs; Anne C. Marshall, Caddice-fly larvae; Paul S. Welch, Annelids; John A. Miller, Leeches; J. Paul Visscher, Amphipods and Isopods; H. B. Hungerford, Hemiptera; Donald J. Borror, Odonata nymphs; C. L. Turner, Crayfishes; C. P. Alexander, a crane fly larva; Ruth Marshall, a water mite; B. D. Burks, Beetles; A. G. Böving, Beetle larvae.

The work on the mud and detritus would have been very incomplete if the samples had not been burned free from organic matter by the Ohio Agricultural Experiment Station (Wooster), by courtesy of G. W. Conrey. The writers are deeply indebted to Carl L. Hubbs, of the Museum of Zoology of the University of Michigan, for a manuscript list of the fishes of Lake St. Clair, and to Milton B. Trautman, of the Franz Theodore Stone Laboratory, for information on the nomenclature of western Lake Erie fishes.

[2]This community name is purely provisional. If further study pointed to the control by fishes, something like Cyprinus-Aplodinotus-Hexagenia would be appropriate.

BIBLIOGRAPHY

Baker, F. C. 1916. The relation of mollusks to fish in Oneida Lake. N. Y. State College of Forestry, Tech. Pub. No. 4, 16: 1–366.

Blegvad, H. 1914. Food and conditions of nourishment among the communities of invertebrate animals found on or in the sea bottom of Danish waters. Rep. Dan. Biol. Sta., 22: 41–78.

Brown, C. J. D., Clarence Clark, and Bruce Gleissner. 1938. Size of certain naiades from western Lake Erie in relation to shoal exposure. Am. Mid. Nat., 19: 682–701.

Cahn, A. R. 1929. The effect of carp on a small lake. The carp as a dominant. Ecol., 10: 271–274.

Clements, F. E., and V. E. Shelford. 1939. Bio-Ecology, New York.

Eddy, Samuel. 1934. A study of fresh water plankton communities. Ill. Biol. Mon., 12: 1–93.

Gersbacher, W. M. 1937. The development of stream communities in central Illinois. Ecol., 18: 359–390.

Krecker, F. H. 1924. Conditions under which *Goniobasis livescens* occurs in the island region of Lake Erie. Ohio Jour. Sci., 24: 299–310.

1928. Periodic oscillations in Lake Erie. Ohio St. Univ., The Franz Theodore Stone Lab., Contrib. No. 1, 1–22.

1931. Vertical oscillations or seiches in lakes as a factor in the aquatic environment. Ecol., 12: 156–163.

Krecker, F. H., and L. Y. Lancaster. 1933. Bottom shore fauna of western Lake Erie: A population study to a depth of six feet. Ecol., 14: 79–93.

Needham, J. G. 1901. Aquatic insects of the Adirondacks. N. Y. State Mus. Bull., 47.

Needham, J. G., and R. O. Christenson. 1927. Economic insects in some streams of northern Utah. Utah Agr. Exp. Sta. Bull., 201: 1–36.

Pearse, A. S. 1939. Animal ecology, New York.

Petersen, C. G. J. 1918. The sea bottom and its production of fish food. Rep. Dan. Biol. Sta., 25: 1–62.

Petersen, C. G. J., and P. B. Jensen. 1911. Valuation of the sea. I. Animal life of the sea-bottom, its food and quantity. Rep. Dan. Biol. Sta., 20: 1–76.

Pieters, A. J. 1894. The plants of Lake St. Clair. Bull. Mich. Fish. Com., 2: 1–12.

Ricker, W. E. 1932. Studies of trout lakes and ponds. Univ. of Toronto Studies Biol. Ser. Pub. Ont. Fish. Res. Lab., 36: 146–151.

Shelford, V. E. 1911a. Ecological succession. I. Stream fishes and the method of physiographic analysis. Biol. Bull., 21: 9–35.

1911b. Ecological succession. II. Pond fishes. Biol. Bull., 21: 127–151.

1911c. Ecological succession. III. A reconnaisance of its causes in ponds with particular reference to fish. Biol. Bull., 22: 1–38.

1913. Animal communities in temperate America. Chicago. Reprinted, 1937, with notes and new bibliography.

Shelford, V. E., and Samuel Eddy. 1929. Methods for the study of stream communities. Ecol., 10: 382–391.

Turner, C. L. 1920. The distribution, food and fish associates of young perch in the Bass Island region of Lake Erie. Ohio Jour. Sci., 22: 137–152.

Essentials of Astronomy

In "Essentials" Mr. Duncan has condensed and simplified the treatment of the material included in his more detailed book on the same subject. The result, on the whole, is good. Other authors have attempted to do the same less successfully. Mr. Duncan has had the advantage of writing another text similar to although more difficult than his "Essentials" and the treatment of the latter shows evidence of the experienced hand.

Objectively speaking, the book is good for the following reasons: First, the language is simple and straightforward. The story is told quickly before the reader has a chance to become confused. Second, the choice of material is such that it encourages observation by the reader. This is highly desirable in the opinion of the reviewer. Much of recent writing tends in the fairy tale direction, taking the reader farther from his personal experiences rather than closer to it. Third, the text is leavened by many delightful quotations from classic literature that continually suggests the inspiration which came to those who looked for and saw the phenomena of which the author speaks.

This book is strongly recommended to all, young and old, who have wished for a pleasant but not too profound acquaintance with the objects in the skies above us.—*C. E. Hesthal.*

Essentials of Astronomy, by John Charles Duncan, pp. 181. Harper and Brothers, New York, 1942. $1.85.

THE ATTRACTION OF FISHES BY DISPOSAL PLANT EFFLUENT IN A FRESH WATER LAKE

I. S. H. METCALF[1]

In his paper of 1930 on the phytoplankton and pollution in Presque Isle Bay, Lake Erie, Gottschall pointed out the fact that fishes are directly or indirectly dependent upon microplankton, macroplankton, and bacteria for food material; that larger fish live upon the smaller plankton consumers, or, in some cases upon the plankton organisms themselves.

The deleterious effects of sewage pollution upon living organisms in rivers and streams have been described by Richardson (1921) in a paper discussing the changes which occurred in the Illinois River as a result of the addition of great amounts of raw sewage to its water. Agersborg (1929) gives us exactly the reverse picture in his report of great improvement in the condition of the same river below Decatur, Illinois, after the installation of a sewage disposal plant in that city. Previous to the installation raw sewage had been discharged directly into the river.

The effects of domestic sewage, however, upon the open waters of a large lake are bound to differ from those upon the confined waters of a stream. Where there is constant aeration through wave action the chances of depletion of the oxygen supply in a body of water which seldom freezes over its entire surface for long are small indeed. In such a case the addition of purely domestic sewage should tend to make the water more productive. This is partly borne out in the work of Gottschall, who found a rich phytoplankton in Presque Isle Bay. This bay is contaminated with sewage from the city of Erie, Pa., and yet even in this relatively confined body of water there is no evidence of anaerobic respiration.

THE PROBLEM

For many years the writer has observed that each late summer and fall the effluent from the sewage disposal plant of the city of Lakewood, Ohio, on the shore of Lake Erie, attracts large numbers of lake fishes, the most abundant of those attracted being the white bass (*Lepibema chrysops* Raf.) and the small lake minnows. At this time, when the annual run of white bass occurs these fish, although often seen along the shore line of the lake, appear in great abundance in the turbid waters of the disposal plant effluent where it mixes with the lake water, sometimes splashing out of the water after the minnows, and sometimes swimming slowly back and forth through the cloudy effluent. Many fishermen in the vicinity of Lakewood take advantage of this schooling of *Lepibema* and catch quantities of the fish by casting or trolling with small lures, near the outlet.

The question arose as to whether the white bass feed upon small particles of solid matter in the effluent itself, upon plankton organisms numerous in the vicinity of the outlet, or upon lake minnows which may be attracted to the place either by effluent or by plankton organisms. It was thought that a comparison of the water in the region of the effluent outlet with that in the open lake might indicate a difference with respect to the abundance of such plankton forms as serve as food for small fishes.

The effluent from the Lakewood sewage disposal plant is discharged into Lake Erie at a point, under water, about half a mile from shore. The liquid is conveyed to the point of discharge through a three-foot main. At the end of this main

[1]Western Reserve University, Cleveland, Ohio, and The Citadel, Charleston, S. C.

there is a series of upward-pointing openings so that the effluent is forced toward the surface of the lake in several streams. The lake water here is about four meters deep. The points of effluent discharge as seen from a boat are marked by a series of muddy slicks on the water, each slick being between six and ten feet in diameter depending upon the rate of flow of the effluent and its temperature relative to that of the lake water. The slow currents in Lake Erie which may arise due to wind or to changes in barometric pressure may cause the water to one side of the line of slicks to remain clear while the water on the downcurrent side is turbid, muddy gray, and filled with bits of bacterial slime and such articles as are not digested in the Imhoff tanks of the disposal plant or are not removed by the gratings at the inlet to the plant. The flow of effluent is not constant, its volume being affected considerably by the amount of rainfall in Lakewood, since many of the older parts of the town have storm and sanitary sewage lines combined.

EQUIPMENT AND METHODS

The investigation was divided into two portions. During the summer of 1938 various places along the shore of Lake Erie in the region of Lakewood, Ohio, were visited by boat in order that some one station might be established whose water would be little apt to be affected by surface water and by water from Rocky River, which empties into the lake just west of the city. Finally a point about two miles from shore and almost due north of the effluent outlet was decided upon and designated as *Station A*. The other station, *Station B*, was in the muddy drift of the effluent, sometimes on one side of the outlets, sometimes on the other, depending upon the direction of the current in the lake. All of the recorded hauls and collections were made when the water at *Station A* was clear and clean, and when that at *Station B* could clearly be seen to contain effluent, as revealed by its gray color and high turbidity.

During the white bass seasons of 1938 and 1939 the stomach contents of a number of white bass and lake minnows were examined in order that their feeding habits might be determined. In this way any plankton organisms which are most important as food for these fishes could be chosen and used as a basis for the study of plankton organisms at the two stations.

The equipment used during the actual collecting trips which were made during the summer of 1939 included an eight-foot wooden dinghy with a small outboard motor; a twelve-inch conical plankton net made of number 8 bolting cloth and equipped with a tubular canvas sleeve at the small end for use with fruit jars; a thermometer and water bottle for determining water temperatures at and below the surface; and a set of wide-mouth cork stoppered bottles for preserving the material taken during the various hauls. Laboratory equipment consisted of a compound microscope and a binocular dissecting microscope used in examining stomach contents of minnows and white bass which were taken in the drift of effluent. In addition to this, a standard 1 ml. Rafter counting cell was used with a ruled ocular disk for counting the catches.

After many trials of different methods of collecting and of keeping the hauls uniform, collections were made on the average of once a week through the latter part of June, through July, August and September of 1939. Those collections in August and September were made at a time when the white bass were abundant in the drift of effluent and could be taken there with a small, shining lure. Collections which were made in July were not recorded because of an uncertainty in the method of handling the counts. The few collections in June are presented in tabular form but are not included in the graphs because of their separation from the later collections with reference to time.

Each collection consisted of a haul with the number 8 net at a level of about three feet below the surface of the water. The haul was made with the outboard

motor running very slowly and at a speed that could easily be duplicated for each collection. The haul lasted two minutes. When the wind blew hard enough to affect the path of the boat, hauls were made cross wind. For the sake of convenience in handling each catch only one-half of it was preserved, care being taken that the catch was completely mixed before the partition was made. The portion of each catch to be preserved was placed in a 60 ml. wide-mouthed bottle and enough formalin was added to give an approximately 5% solution. Bottles were given temporary labels on the trip and permanent ones later. During each trip water temperature was taken at the surface and the approximate wind velocity and direction were estimated and recorded, together with the direction of the current of the water.

The number of actual laboratory counts made on each catch was fifteen, and the method of procedure was as follows: Five ml. of the catch were diluted to twenty-five ml. with tap water. Three one ml. samples of this diluted catch were used and five random counts of each were made in the Rafter Cell. All fifteen counts on each catch were averaged and the average number was multiplied by the factor number (109.8) which gives the theoretical number of organisms per liter of water on the basis of the assumption that the net used was one hundred per cent efficient and that all of the water in its one hundred and sixty foot path was filtered through it. In the counting of *Anabaena*, the blue-green alga, complete circlets of cells were counted as one unit, and then the final number was multiplied by 25, the average number of cells per circlet. Similarly, for the diatom *Asterionella*, each whorl of frustules was counted as one unit, and the resulting average multiplied by six, the average number of cells in a whorl. The resulting figures have been plotted against the times at which collections were made. See Figs. 1 through 7.

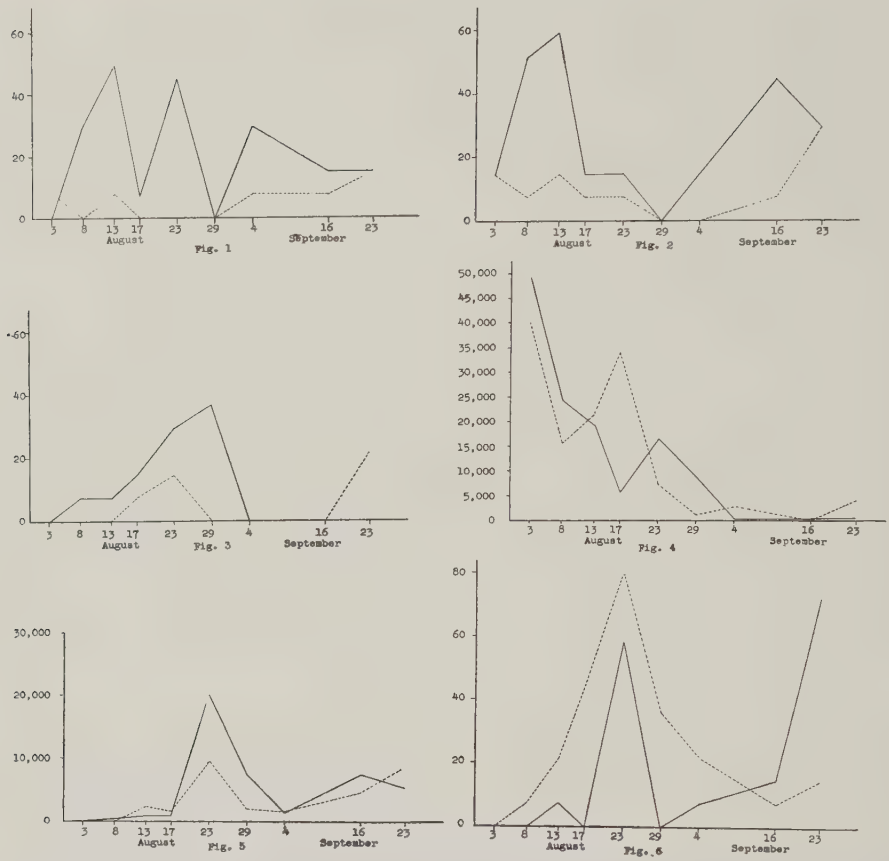
RESULTS

The examination of fish stomach contents which was carried out during the summer revealed (a) that although certain algae are apparently taken by minnows swimming in the region of the effluent outlet, more often the food of these fishes is composed of Entomostraca, and (b) that although the white bass takes the spinning lure readily and many times is found to contain only lake minnows, there appears in about half of the fish examined a granular, brownish mush. Microscopic examination shows this mush to be made up of enormous numbers of cladoceran skeletons.

Because of these findings it was decided that the actual comparison of the plankton populations at stations *A* and *B* should be made with reference to a few particular organisms or organism types. For this comparison the phytoplanktonts *Anabaena*, *Asterionella*, *Ceratium* and *Dinobryon* were chosen, and likewise the zooplankton groups Cladocera, Copepoda, and Rotifera. With reference to the algae considered no attempt was made to determine the species, and in the case of the animals, the organisms were noted only with respect to their groups.

In the table and graphs expressing the results of the counts the figures stand for the number of organisms per liter of lake water, based on the assumption that the net was one hundred percent efficient. Although it is known that this was certainly not the case, since the hauls were all made as nearly alike as possible the inefficiency of the net can be treated as constant error.

From Figs 1, 2, and 3, it will be seen that the Cladocera, Copepoda, and Rotifera were more numerous in the region of effluent discharge than they were in the open lake at a distance from this region. In the graphs the solid lines indicate organism counts at *Station B*, broken lines indicate organism counts at *Station A*. Figures for the Cladocera and Copepoda were tested and found to be statistically significant according to the method presented by Fisher (1930) for appraising small samples. Probable errors for these two groups were found to be 3.7% and 4%



FIGS. 1–6. (1) Graph expressing numbers of Cladocera per liter of water plotted against collection dates. (2) Graph expressing numbers of Copepoda per liter of water plotted against collection dates. (3) Graph expressing numbers of Rotifera per liter of water plotted against collection dates. (4) Graph expressing numbers of *Anabaena* per liter of water plotted against collection dates. (5) Graph expressing numbers of *Asterionella* per liter of water plotted against collection dates. (6) Graph expressing numbers of *Ceratium* per liter of water plotted against collection dates.

All figures calculated on basis that the net used was 100 per cent efficient. In all graphs broken lines refer to counts from *Station A;* solid lines in all graphs refer to counts from *Station B*.

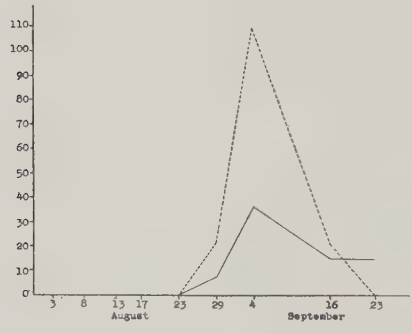


FIG. 7. Graph expressing numbers of *Dinobryon* per liter of water plotted against collection dates. Figures calculated on basis that the net used was 100 per cent efficient. Broken lines refer to counts from *Station A;* solid lines refer to counts from *Station B*.

respectively. Although the probable error for the figures on Rotifera is too high (80%) to allow for confidence, during the entire month of August and the first part of September the individuals appear much more numerous at *Station B* than at *Station A*.

Calculations of significance for the data on the algae indicate that the probable error is much too large to permit us to depend on the figures, possibly because of the enormous variation which occurred from collection to collection. The graphs are included, however, to indicate that variation. (Figs. 4, 5, 6, and 7.) It will be seen that the figures for the diatom *Asterionella* and the blue-green alga *Anabaena* are close together at the two stations, whereas *Ceratium* and *Dinobryon* gave higher counts at the open water station.

TABLE I

In this table are presented the data for those collections made on dates not included in the graphs. Three dates of collection are recorded, the 17th, 19th, and 25th of June, 1939. Figures in the column marked *Station A* represent organisms per liter of water in the open lake. Those in the column marked *Station B* indicate organisms per liter of water in the drift of effluent. As explained in the text, the figures are calculated on the assumption that the net used is 100 per cent efficient.

Organisms	Date (1939)	Station A	Station B
Cladocera	6/17	21.960	7 247
	6/19	7.247	40.187
	6/25	219.600	197.640
Copepoda	6/17	73.126	951.526
	6/19	43.920	7.247
	6/25	87.840	51.167
Rotifera	6/17	505.080	95.087
	6/19	397.080	36.563
	6/25	1024.434	329.400
Anabaena	6/17	0.000	0.000
	6/19	0.000	0.000
	6/25	0.000	0.000
Asterionella	6/17	9045.324	435.466
	6/19	435.467	1139.724
	6/25	0.000	0.000
Ceratium	6/17	14.603	0.000
	6/19	0.000	0.000
	6/25	0.000	0.000
Dinobryon	6/17	124.034	0.000
	6/19	7.247	0.000
	6/25	0.000	0.000

Since records of the approximate velocity and direction of the wind and the direction of current were made at each haul, later compared and checked with those published by the Weather Bureau at Cleveland, Ohio, an attempt was made to find some correlation between wind and drift direction and the abundance of organisms at the two stations. Such a correlation could not be found. Inasmuch as the water temperature varied only slightly during the period at which collections were made, it is not believed that there is any correlation to be made with reference to temperature.

From the graphs and table presented it will be noted that only those organisms which live on particulate food appear to be effected by disposal plant effluent in the water. It may be said that the bacteria which undoubtedly exist in large numbers in this effluent, together with numerous protozoa (Agersborg, 1929) are capable of supporting a large population of entomostracans and rotifers. Plant nourishing materials are doubtless discharged into the lake water as well by the disposal plant, but for some reason the plant life is unable to take immediate advantage of this food supply. It is suggested that similar comparative experiments be made on the waters of the effluent drift both near and at a distance from the actual outlet. Such investigations might indicate an increase in the phytoplankton in the water bearing more diluted effluent.

From Table I it will be noticed that the figures for June, 1939, as regards Rotifera, Cladocera, and Copepoda do not exactly follow those for the latter part of the season. No attempt is made to explain this discrepancy. It is suggested, however, that this abundance of organisms may have been washed out away from shore as a result of spring rains. Also, it would be only reasonable to expect that the bacterial count of the entire lake, both in deep and in shore waters, is high in early summer, and is capable of supporting a large population of those forms dependent upon particulate food.

SUMMARY

1. An attempt is made to explain the apparent attraction of white bass by the disposal plant effluent emptied into Lake Erie by the city of Lakewood, Ohio.

2. A comparison of the plankton population in the region of the effluent outlet is made with that at a point in the open lake which is believed to be unpolluted by effluent.

3. Four genera of algae and three groups of zooplankton organisms are used as bases for this comparison.

4. Although the numbers of algae and of Rotifera are not found to be significantly greater at the effluent outlet than in the open lake, the numbers of Cladocera and Copepoda were found, during the months of August and September, to be significantly greater around the effluent outlet.

5. It is concluded that these forms which live on particulate food are supported in abundance by the numerous bacteria and protozoa discharged into the lake in disposal plant effluent. These plankton forms attract fishes.

6. Although an attempt is made to correlate the relative abundance of the organisms considered at the two stations at which collections were made, with wind and current directions, no correlation is found.

BIBLIOGRAPHY

Agersborg, H. K. P. 1929. The biology of sewage disposal; preliminary report. *Trans. Amer. Mic. Soc.*, 48: 158.

Fish, C. J. 1929. Cooperative survey of Lake Erie, session 1928; preliminary report on the. *Bull. Buffalo Soc. Natural Sciences*, 14: no. 3, 1–228.

Fisher, R. A. 1930. *Statistical Methods for Research Workers.* Oliver and Boyd, London.

Forbes, S. A. and Richardson, R. E. 1919. Some recent changes in Illinois river biology. *Bull. State of Ill. Division of Nat. Hist. Survey*, 13: 139–156.

Gottschall, R. Y. 1930. Preliminary report on the phytoplankton in Presque-Isle Bay and Lake Erie. *Proc. Penn. Acad. Sciences*, 4: 69–79.

1933. Limnological studies at Erie, Pa. *University of Pittsburgh Bull.*, 29: no. 3, 101–109.

Kirtland, J. P. 1844. Description of the fishes of Lake Erie, the Ohio River and their tributaries. *Boston Journal of Nat. Hist.*, 4: 231–240.

1846. Ibid., 5: 265–276; 330–344.

1850. "Fishes of Ohio." *The Family Visitor*, 1: no. 7, 53 (February 14, 1850).

Krecker, F. H. 1928. *Periodic Oscillations in Lake Erie.* Ohio State University Press, Columbus, p. 1–22.

Krecker, F. H. and Lancaster, L. Y. 1933. Bottom shore fauna of western Lake Erie: A population study to a depth of six feet. *Ecology*, 14: 79–93.
Landacre, F. L. 1908. The protozoa of Sandusky Bay and vicinity. *Proc. Ohio Acad. Sci.*, 4: no. 10, 421–472.
McCormack, L. M. 1892. Descriptive list of the fishes of Lorain County, Ohio. *Oberlin College Bulletin*, no. 2, "*Fishes, Anatomy and Development.*"
New York State Conservation Department. 1929. *A Biological Survey of the Erie-Niagara System*; Supplemental to 18th Annual report. Albany. J. B. Lyon Co.
Richardson, R. E. 1921. Changes in the bottom and shore fauna of the middle Illinois river and its connecting lakes since 1913–1915 as a result of the increase southward of sewage pollution. *Bull. Ill. State Lab. Nat. Hist.*, vol. 14, art. 4.
Stehle, Mabel E. 1923. Surface plankton protozoa from Lake Erie in the Put-in-Bay region. *Ohio Jour. Sci.* 23: 41–54.
Tiffany, L. H. 1934. *The Plankton Algae at the West End of Lake Erie.* Ohio State University Press. Columbus.
1937. The filamentous algae of the west end of Lake Erie. *Amer. Midland Naturalist*, 18: 911–951.
Vorce, C. M. 1880. *Some Observations on the Minute Forms of Life in the Waters of the Lakes.* Kirtland Society of Natural Sciences, Cleveland.
Ward, H. B. and Whipple, G. C. 1918. *Fresh Water Biology.* John Wiley and Sons, Inc., London.

A New Book on Parasitic Animals

This text for college students is a quite thorough, systematic treatment of those members of the animal kingdom that live a parastiic life. It, therefore contains much information on parasites which are not mentioned in books stressing the medical and veterinarian aspects of parasitology, and this material will be of particular interest to zoologists. Many groups are considered as to order or family only, but some important species are discussed. There are chapters on methods and techniques.—*Carl Venard.*

Introduction to Parasitology, by A. S. Pearse. ix+357 pages, 448 figs. 1942. Charles C. Thomas, Springfield, Ill. Price, $3.75.

Modern Physics

In this book the author has presented in very readable form a summary of the material which might well represent the content of a semester's work to follow a year's work in College Physics. Stress has been placed on the experimental side of the picture, but lengthy leviations in the theory underlying these experiments are omitted, the work being largely descriptive in character and the mathematics not being beyond the attainments of the ordinary college junior.

The book is well organized. It contains excellent summaries of the work done in determining many of our important physical constants and several pages of tables bringing the data up to date. It is unfortunate that no problems have been included; there is a crying need for problems in works of this nature.

The book is well-printed on excellent paper and is carefully bound.—*J. B. Green.*

The "Particles" of Modern Physics, by J. D. Stranathan, Ph.D. The Blakiston Co., Philadelphia. $4.00.

DROSOPHILA AND THE COURSE OF RESEARCH

A. H. HERSH,
Biological Laboratory, Western Reserve University

The publication of an exhaustive bibliography[1] on the genetics of Drosophila up to the end of the year 1938 gives an opportunity to trace the course of scientific productivity in certain of its quantitative relations. The pertinent data for those aspects to which this note is limited are given in Table I, where the number of papers published each year and the number of authors publishing them are listed on the left hand side, and on the right hand side is given the number of authors credited with the number of titles indicated. The earliest reference in the bibliography is dated 1818 and for the interval from that date to 1900 there is a total of 12 titles. In 1900 the modern work on Drosophila began.[2] One paper was published in each of the years 1900, 1902 and 1903. Table I begins with 1905, the first year in which more than one paper was published. In a few years thereafter, by 1910–1911, Drosophila was already in the forefront of genetic research, mainly because of the work of Morgan and associates.

When the data for the number of papers published each year since 1910 are plotted semilogrithmically against time it is found that the points fall within a narrow band with straight and approximately parallel edges. In other words the data conform roughly to the simple exponential relation, called sometimes the compound interest law,

$$y = ae^{rt} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

in which y is the number of papers, t the time, e the base of the system of natural logarithms, a the value of y when $t = 0$ (taken as 1910), and r the relative rate of increase. Furthermore, when y is taken as the number of authors, it is found that the data likewise conform approximately to equation (1). The numerical values of the constants for the two sets of data, determined by the method of averages, follow.

$$\text{papers,} \quad a = 15.5; r = 0.106$$

$$\text{authors,} \quad a = 9.5; r = 0.112$$

The result shows that the number of papers published per year increased at a compound interest rate of about 10.6 percent per year from 1910 to the end of 1938; a similar figure for the number of authors is 11.2 percent per year. This treatment neglects a certain irregular periodicity in the data. The high points of this periodicity occurred in the years 1911–14, 1929–30, and 1935–37. The first one mentioned inaugurated the work, the next is no doubt a consequence of Muller's discovery in 1927 that x-rays produce a great increase in the rate of mutation, while the last one is in large part the result of a stimulation given to cytogenetic investigation by Painter's discovery of the importance of the salivary gland chromosomes.

---

[1]Muller, H. J. 1939. Bibliography on the genetics of Drosophila, p. 132. Oliver and Boyd, Edinburgh.

[2]Davenport, C. B. 1941. The early history of research with Drosophila. Science, N. S., 93, pp. 305 306.

Since the two sets of data conform in this way to equation (1) it immediately follows that the simple power function

$$y = bx^k \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

is an approximate description of their relation to each other. In this equation y is taken as the number of papers and x as the number of authors for the years indicated; b and k are constants. The value of k with its standard error is 0.95 ± 0.03. Although this value does not differ significantly from one, it may nevertheless be the expression of a real trend, in which case it would be a rough measure of the increasing collaboration in the writing of papers, and as such is better expressed by its reciprocal, 1.05. The numerical value of b is 1.8; it is a rough measure of the extent to which authors tend to publish more than one paper per year.

TABLE I

Years	Titles	Authors	Papers	Authors
1905	3	3	1	418
1906	3	7	2	126
1907	6	5	3	69
1908	6	6	4	44
1909	4	4	5	27
1910	10	8	6	26
1911	22	15	7	13
1912	19	12	8	14
1913	27	16	9	10
1914	30	15	10	8
1915	27	18	11	5
1916	21	15	12	5
1917	40	26	13	6
1918	32	22	14	4
1919	45	19	15	7
1920	45	28	16	1
1921	48	29	17	5
1922	43	40	18	2
1923	64	45	19	3
1924	47	37	20	5
1925	62	50	21	1
1926	65	48	22	2
1927	78	60	23	2
1928	92	70	24	3
1929	134	90	25	1
1930	171	98	26	2
1931	137	108	27	2
1932	160	104	30	2
1933	134	108	35/38/41/49/	.....
1934	207	136	52/54/67/	.....
1935	315	201	69/89/96/	.....
1936	312	200	100/102/131/	.....
1937	333	231	1 author each.	.....
1938	233	180	.....	.....

The data on the right hand side of Table I likewise conform to equation (2). When the logarithms of the number of authors are plotted against the logarithms of the number of papers to their credit in the entire bibliography then it is found that the first ten points, which include about 90% of all authors, fall on or quite close to a straight line of negative slope. When the constants b and k are determined by the method of averages for the first ten pairs of values, it is found that

the value of k is —1.69 and that of b is 427. Calculation from these values shows that the curve cuts the x-axis at 36. Since this value will undoubtedly increase as the papers continue to accumulate, it seems clear that the entire curve showing the relation will reach higher and higher levels but the slope will undergo an algebraic increase, and approach —1.0 as a limiting value.

Any prediction from the exponential curves is hazardous because of the impossibility of knowing when a point of inflection may be reached. From the data in hand, however, an extrapolation to 1945 indicates that some 633 papers will be published in that year by about 480 authors. One need not be unduly pessimistic to doubt that the present diversion of the energies of the world to war will permit this high level of vigor and vitality to be maintained in such a purely peacetime enterprise as research on Drosophila.

The data show that research, an important sphere of man's social activity, in certain of its quantitative relations conforms to two functions which are among the most frequent types met with in the physical and biological sciences.

Mankind through the Zoologist's Looking-glass

So many social questions are dealt with today as though conditions are entirely of man's own making, and their correction is within man's power, that it is refreshing to find the Zoologist's answers given a place in our current writings. If mankind is primarily another species in the animal kingdom, why are not his problems more often approached with this basic assumption in the foreground?

The reader of James G. Needham's recently published book, "About Ourselves," will be led to understand how integral a part of the animal kingdom *Homo sapiens* is. The simple, clear and pleasantly humorous style leads one to see how each bodily function of man has its counterpart among animals,—and yet how man goes far beyond other species in his instincts, folkways and reason, even though these distinctions are matters of degree rather than kind.

Man is pictured as a species in which social behavior is as inherent as is his erect posture. Human behavior emerges as largely instinctive, and upon our instincts are superimposed folkways, and upon these, rational behavior. Out of folkways have evolved language, money and customs, upon which much that is peculiarly human is based.

Especially pertinent at this time, war, government and religion are shown to be natural outgrowths of the expression of man's behavior pattern. All three,—warfare, government, and religion, are social enterprises,—with their roots in the biology of the species.

In the midst of our present war hysteria,—to read the last half of this book, if no more, is to get the feeling of coming out suddenly into the light, of breathing clean air again,—of putting first things first. This book won't stop any war, but it will clarify the underlying issues considerably. Sociologists, economists, and politicians especially, should read, "About Ourselves."—*J. W. Price.*

About Ourselves, by James G. Needham. xi+276 pp. Lancaster, Pa., The Jacques Cattell Press, 1941. $3.00.

ADDITIONS TO THE REVISED CATALOGUE OF OHIO VASCULAR PLANTS. X.[1]

CLYDE H. JONES

In spite of the unstable and unpredictable status of transportation and employment, the enthusiasm and activity of the amateur botanists throughout the State have not abated during the past year. This fact is amply proven by the many collections of carefully prepared specimens which have been contributed to the State Herbarium—specimens representing the vegetation of all of the physiographic divisions and ecological habitats of Ohio.

Likewise, the usefulness of the General Herbarium has been substantially augmented by a collection of California plants contributed by Dr. Elton Paddock, of Berkeley, California, and by specimens received from exchange with the New York Botanical Garden and the National Herbarium. The extensive addition of grass specimens from the National Herbarium has made our collection of this economically important family one of the best.

Indeed surprising are the number of erroneous conceptions quickly dispelled and the number of interesting problems introduced when we investigate the distribution of our native plants. Innumerable questions relating to migration routes, dates of migration, and factors which have favored or inhibited the establishment of many of our native species remain unsolved.

We seldom realize, however, that these same questions, when applied to some of our introduced plants, are just as intriguing academically and certainly more important economically. Even the most casual observation will prove that many of these plants are as exacting in their habitat requirements as our native ones. Many weeds which are of negligible importance in some sections of the state frequently become economic challenges of real magnitude in others, and the problems associated with their migration and eradication are constantly with us.

Observations concerning the establishment and subsequent migrations of *Hieracium aurantiacum*, the Orange Hawkweed, illustrate the value of having a county-by-county "weed flora" incorporated in our herbarium. According to these records, this beautiful but entirely too aggressive European invader made its first appearance in Ohio near Oswell, Ashtabula County, in 1895. Since that time it has migrated and become established in the meadows and pastures of nine adjoining counties. From this type of information one can predict, with reasonable certainty, that this plant will invade additional plateau counties if control measures are not applied.

The following list of plants represents a majority of the new county and state records which have been added to the State Herbarium during the past year:

1. *Ophioglossum vulgatum* L. Adder-tongue. Hocking Twp., Fairfield Co. Chas. R. Goslin. Salem Twp., Meigs Co. Clyde H. Jones.
5. *Botrychium obliquum* Muhl. Oblique Grape-fern. Black Hand Gorge, Licking Co. Chas. R. Goslin.
6. *Botrychium dissectum* Spreng. Cutleaf Grape-fern. Waterloo Twp., Athens Co. Walter P. Porter.
7. *Botrychium virginianum* (L.) Sw. Virginia Grape-fern. Highland Co. Katie M. Roads. Dellroy, Carroll Co. Clyde H. Jones.
8. *Osmunda regalis* L. Royal-fern. Goodhope Twp., Hocking Co. Chas. R. Goslin.
11. *Polypodium virginianum* L. Virginia Polypody. Holmes Co. E. P. MacArthur.
14. *Phegopteris hexagonoptera* (Mx.) Fee. Broad Beech-fern. Laurel Twp., Hocking Co. Chas. R. Goslin. Dellroy, Carroll Co. Clyde H. Jones.

[1]Papers from the Department of Botany, The Ohio State University, No. 448.

16. *Adiantum pedatum* L. Maidenhair-fern. Athens Twp., Athens Co. B. B. Bodel.
20. *Anchistea virginica* (L.) Presl. Virginia Chain-fern. Stark Co. Don M. Brown.
25. *Asplenium platyneuron* (L.) Oaks. Ebony Spleenwort. Dellroy, Carroll Co. Clyde H. Jones.
29. *Athyrium thelypteroides* (Mx.) Desv. Silvery Spleenwort. Pike Co. Gordon S. Crowl. Dellroy, Carroll Co. Clyde H. Jones.
32. *Camptosorus rhizophyllus* (L.) Link. Walking-fern. Hocking Co. Chas. R. Goslin.
35. *Dryopteris cristata* (L.) Gr. Crested Shield-fern. Dellroy, Carroll Co. Clyde H. Jones.
37. *Dryopteris goldiana* (Hook.) Gr. Goldie's Shield-fern. Pike Co. Gordon S. Crowl.
43. *Dennstaedtia punctilobula* (Mx.) Moore. Boulder-fern. Pike Co. Gordon S. Crowl.
44. *Cystopteris bulbifera* (L.) Bernh. Bulbiferous Bladder-fern. Ross Co. Gordon S. Crowl.
45. *Cystopteris fragilis* (L.) Bernh. Fragile Bladder-fern. Pike and Ross Co. Gordon S. Crowl. Lancaster, Fairfield Co. Chas. R. Goslin.
48. *Onoclea sensibilis* L. Sensitive-fern. Clay Twp., Perry Co. Chas. Reutinger.
49. *Marsilea quadrifolia* L. European Marsilea. Franklin Co. Jane Roller. Introduced.
54. *Equisetum praealtum* Raf. Great Scouring Rush. Revenge, Fairfield Co. John H. Schaffner. Tillerman Bog, Greenville, Darke Co. Dale W. Jenkins.
56. *Equisetum nelsonii* (A. A. Eat.) Schaff. Nelsons' Scouring-rush. Ross Co. Gordon S. Crowl.
62. *Lycopodium lucidulum* Mx. Shining Club-moss. Monroe Co. Clyde H. Jones.
67.2. *Lycopodium tristachyum* Pursh. Jefferson Twp., Knox Co., F. J. VanVoorhes.
73. *Pinus strobus* L. White Pine. Grandview Twp., Washington Co. L. E. Hicks.
83. *Sagittaria latifolia* Willd. Broad-leaf Arrow-head. Loudenville, Ashland Co. Anonymous. Pike Co. Gordon S. Crowl.
87. *Alisma subcordatum* Raf. American Water-plantain. Wood Co. R. E. Shanks. Pike and Ross Co. Gordon S. Crowl.
108. *Potamogeton dimorphus* Raf. Spiral Pondweed. Stark Co. Don M. Brown.
112. *Najas flexilis* (Willd.) Rost. & Schm. Slender Najas. Ottawa Co. Don M. Brown.
116. *Nymphaea advena* Sol. Large Yellow Water-lily. Clinton Twp., Wayne Co. Ed. MacArthur.
120. *Vallisneria spiralis* L. Tape-grass. Franklin Co. L. E. Hicks.
129. *Spathyema foetida* (L.) Raf. Skunk Cabbage. Eden Twp., Licking Co. Warren Abbott.
131. *Arisaema dracontium* (L.) Schott. Green-dragon. Trumbull Co. R. E. Shanks.
132. *Arisaema triphyllum* (L.) Torr. Jack-in-the-pulpit. Highland Co. Katie M. Roads. Athens, Athens Co. Warren Abbott.
134. *Lemna trisulca* L. Ivy-jointed Duckweed. Portage Co. Chas. Goslin.
136. *Lemna minor* L. Lesser Duckweed. Ross Co. Gordon S. Crowl.
141. *Scirpus cyperinus* (L.) Kunth. Wool-grass Bulrush. Ross Co. Gordon S. Crowl.
143. *Scirpus atrovirons* Muhl. Dark-green Bulrush. Ross Co. Gordon S. Crowl.
146. *Scirpus validus* Vahl. Great Bulrush. Ross Co. Gordon S. Crowl.
157. *Eleocharis compressa* Sull. Flat-stemmed Spike-rush. Portage Co. Don M. Brown.
160. *Eleocharis reclinata* Kunth. Matted Spike-rush. Ross Co. Gordon S. Crowl. Wood Co. R. E. Shanks.
168. *Cyperus strigosus* L. Straw-colored Cyperus. Hocking Co. Don M. Brown.
170. *Cyperus filiculmis* Vahl. Slender Cyperus. Adams Co. Don M. Brown.
199. *Carex muhlenbergii* Schk. Muhlenberg's Sedge. Pleasant Twp., Fairfield Co. Chas. R. Goslin.
223. *Carex sterilis* Willd. Sterile Sedge. Berne Twp., Fairfield Co. Chas. R. Goslin.
229. *Carex tribuloides* Whal. Blunt Broom Sedge. Portage Co. Don M. Brown.
239. *Carex suberecta* (Olney) Britt. Prairie Straw Sedge. Berne Twp., Fairfield Co. Chas. R. Goslin.
243. *Carex strictior* Dew. Tussock Sedge. Portage Co. Don M. Brown.
250. *Carex crinita* Lam. Fringed Sedge. Scioto Co. Katie M. Roads.
256. *Carex pennsylvanica* Lam. Pennsylvania Sedge. Stark and Geauga Co. Don M. Brown.
267. *Carex platyphylla* Car. Broadleaf Sedge. Tuscarawas Co. Don M. Brown.
272. *Carex gracilescens* Steud. Loose-flowered Sedge. Tuscarawas and Stark Co. Don M. Brown.
275. *Carex shriveri* Britt. Shriver's Sedge. Highland Co. Katie M. Roads.
278. *Carex oligocarpa* Schk. Few-fruited Sedge. Laurel Twp., Hocking Co. Chas. R. Goslin.
289. *Carex swanii* (Fern.) Mack. Swan's Sedge. Wood Co. R. E. Shanks.
314. *Carex hystricina* Muhl. Porcupine Sedge. Portage Co. Don M. Brown.
317. *Carex frankii* Kunth. Frank's Sedge. Ross Co. Gordon S. Crowl.
320. *Carex intumescens* Rudge. Bladder Sedge. Spruce Run, Hocking Co. Chas. R. Goslin. Athens Co. Warren Abbott.

323. *Carex lupulina* Muhl. Hop Sedge. Adams and Hocking Co. Don M. Brown. Athens Co. Warren Abbott.
327. *Bromus hordeaceus* L. Soft Chess. Ross Co. Don M. Brown.
328. *Bromus secalinus* L. Common Chess. Wood Co. R. E. Shanks.
333. *Bromus ciliatus* L. Fringed Brome-grass. Stark Co. Don M. Brown.
335. *Bromus tectorum* L. Downy Brome-grass. Ross Co. Don M. Brown.
354. *Poa compressa* L. Flat-stemmed Blue-grass. Conneaut, Ashtabula Co. L. E. Hicks.
365. *Dactylis glomerata* L. Orchard Grass. Wood Co. R. E. Shanks.
366. *Eragrostis pectinacea* (Mx.) Steud. Purple Love-grass. Conneaut River, Ashtabula Co. L. E. Hicks. Belmont Co. E. E. Laughlin. Loveland, Clermont Co. J. F. James. Fairfield Co. Robert and William Goslin.
368. *Eragrostis major* Host. Strong-scented Love-grass. Adams Co. Don M. Brown.
371. *Eragrostis pilosa* (L.) Beauv. Tufted Love-grass. Reported from Lake and Hamilton Co. only. Specimens from Ashtabula, Auglaize, Franklin, Belmont, Tuscarawas, Clermont, and Scioto counties misidentified.
372. *Eragrostis frankii* Steud. Frank's Love-grass. Ross Co. Gordon S. Crowl.
379. *Tridens flava* (L.) Hitchc. Tall Purple-top. Ross Co. Gordon S. Crowl.
381.1. *Cynosurus echinatus* L. Painesville, Lake Co. From Herbarium of Wm. C. Werner, 1889. Introduced.
383. *Danthonia spicata* (L.) Beauv. Common Wild-oat Grass. Wood Co. R. E. Shanks.
393. *Nothoholcus lanatus* (L.) Nash. Velvet-grass. Ross Co. Gordon S. Crowl.
404. *Agrostis alba* L. Red-top Bent-grass. Stark Co. Don M. Brown.
405. *Agrostis schweinitzii* Trin. Thin Bent-grass. Stark Co. Don M. Brown.
406. *Agrostis perennans* (Walt.) Tuck. Upland Bent-grass. Stark Co. Don M. Brown.
480. *Panicum werneri* Scribn. Werner's Panic-grass. Lynx Prairie, Adams Co. A. R. Harper and R. B. Gordon.
482. *Panicum sphaerocarpon* Ell. Round-fruited Panic-grass. Ross Co. Gordon S. Crowl.
496. *Panicum clandestinum* L. Hispid Panic-grass. Ross Co. Gordon S. Crowl.
497. *Panicum latifolium* L. Broad-leaf Panic-grass. Pike Co. Gordon S. Crowl.
503. *Echinochloa crus-galli* (L.) Beauv. Common Barnyard-grass. Ross and Pike Co. Gordon S. Crowl.
507. *Paspalum muhlenbergii* Nash. Muhlenberg's Paspalum. Clinton Co. E. E. Terrell, Jr.
512. *Chaetochloa glauca* (L.) Scribn. Yellow Foxtail-grass. Ross Co. Gordon S. Crowl. Lancaster, Fairfield Co. Chas. R. Goslin.
514. *Sorghum halepense* (L.) Pers. Johnson-grass. Mingo Junction, Jefferson Co. F. P. Taylor. Introduced and established.
516. *Sorghastrum nutans* (L.) Nash. Indian-grass. Hocking Co. John N. Wolfe.
521. *Andropogon virginicus* L. Virginia Beard-grass. Clinton Co. E. E. Terrell, Jr.
522. *Andropogon scoparius* Mx. Little Bluestem. Ross Co. Gordon S. Crowl.
527. *Lilium canadense* L. Canada Lily. Dellroy, Carroll Co. Clyde H. Jones.
530. *Erythronium americanum* Ker. Yellow Adder's Tongue. Athens, Athens Co. Warren Abbott. Pike Co. Gordon S. Crowl.
531. *Erythronium albidum* Nutt. White Dog-tooth Lily. Athens, Athens Co. Warren Abbott.
534. *Allium tricoccum* Ait. Wild Leek. Wood Co. R. E. Shanks. Clinton Co. E. E. Terrell, Jr.
538. *Allium canadense* L. Meadow Garlic. Portage Co. Don M Brown. Berne Twp., Fairfield Co. Chas. R. Goslin.
539. *Allium cernum* Roth. Nodding Onion. Adams Co. Don M. Brown.
541. *Quamasia hyacinthina* (Raf.) Britt. Wild Hyacinth. Belmont Co. Clyde H. Jones. Loudenville, Ashland Co. Anonymous.
544. *Ornithogalum umbellatum* L. Star-of-Bethlehem. Clinton Co. E. E. Terrell, Jr. Hocking Co. Chas. R. Goslin.
555. *Trillium grandiflorum* (Mx.) Salisb. Large Flowered Trillium. Athens, Athens Co. Warren Abbott. Pike Co. Gordon S. Crowl.
556. *Trillium erectum* L. Ill-scented Trillium. Stark Co. Don M. Brown.
561. *Trillium sessile* L. Sessile Trillium. Athens Twp., Athens Co. Warren Abbott. Monroe Co. Clyde H. Jones.
562. *Medeola virginiana* L. Indian Cucumber-root. Athens Co. K. Boyd. Mohican Forest, Ashland Co. James Stevenson.
564. *Uvularia perfoliata* L. Perfoliate Bellwort. Athens, Athens Co. Warren Abbott.
565. *Uvularia grandiflora* Sm. Large-flowered Bellwort. Nelsonville, Athens Co. K. Boyd. Adams Co. Chas. R. Goslin. Mohican Forest, Ashland Co. James Stevenson.
569. *Polygonatum commutatum* (R. & S.) Dietr. Smooth Solomon's-seal. Pike and Guernsey Co. Gordon S. Crowl. North Hill Caves, Athens Co. C. Leben.
570. *Polygonatum biflorum* (Walt.) Ell. Hairy Solomon's-seal. Holmes Co. E. P. MacArthur. Mohican Forest, Ashland Co. J. Stevenson.

571. *Vagnera racemosa* (L.) Mor. False Spikenard. Athens, Athens Co. Warren Abbott.
574. *Unifolium canadense* (Desf.) Greene. False Lily-of-the-valley. Belmont Co. Clyde H. Jones. Morrow Co. R. E. Shanks.
579. *Smilax ecirrhata* (Engelm.) Wats. Upright Smilax. Farnham, Ashtabula Co. L. E. Hicks.
580. *Smilax herbacea* L. Common Carrion-flower. Laurel Twp., Hocking Co. Chas. R. Goslin. Highland Co. Katie M. Roads.
584. *Smilax rotundifolia* L. Round-leaf Greenbrier. Adams and Scioto Co. Katie M. Roads. Geauga Co. Don M. Brown.
588. *Tradescantia virginiana* L. Virginia Spiderwort. Athens, Athens Co. Warren Abbott. Pike Co. Gordon S. Crowl.
589. *Tradescantia pilosa* Lehm. Zigzag Spiderwort. Clinton Co. E. E. Terrell, Jr.
590. *Commelina communis* L. Asiatic Day-flower. Stark Co. Don M. Brown. Fairfield Co. Chas. R. Goslin.
593. *Juncus effusus* L. Common Rush. Berne Twp., Fairfield Co. Chas. R. Goslin. Pike Co. Gordon S. Crowl.
600. *Juncus aristulatus* Mx. Small-headed Grass-leaf Rush. Ross Co. Gordon S. Crowl.
604. *Juncus torreyi* Cov. Torrey's Rush. Berne Twp., Fairfield Co. Chas. R. Goslin.
607. *Juncus brachycephalus* (Engelm.) Buch. Small-headed Rush. Stark Co. Don M. Brown.
608. *Juncus acuminatus* Mx. Sharp-fruited Rush. Ross Co. Don M. Brown.
612. *Juncoides campestre* (L.) Ktz. Common Wood-rush. Geauga Co. Don M. Brown.
618. *Narcissus poeticus* L. Poet's Narcissus. Goodhope Twp., Hocking Co. Chas. R. Goslin.
620. *Dioscorea villosa* L. Wild Yam. Garrettsville, Portage Co. Don M. Brown. Pike and Ross Co. Gordon S. Crowl.
624. *Sisyrinchium graminoides* Bickn. Stout Blue-eyed-grass. Hopewell Twp., Perry Co. Chas. Reutinger. Goodhope Twp., Hocking Co. Chas. R. Goslin. Athens, Athens Co. Warren Abbott.
633. *Iris cristata* Ait. Crested Dwarf Iris. Ross Co. Gordon S. Crowl.
639. *Galeorchis spectabilis* (L.) Rydb. Showy Orchis. Pike Co. Gordon S. Crowl.
652. *Blephariglottis psycodes* (L.) Rydb. Smaller Purple Fringed-orchis. Berne Twp., Fairfield Co. Chas. R. Goslin.
654. *Ibidium cernuum* (L.) House. Nodding Lady's-tresses. Clinton Co. E. E. Terrell, Jr. Champaign Co. Arthur Harper and A. G. Welshimer.
667. *Liparis liliifolia* (L.) Richard. Large Twayblade. Clinton Co. E. E. Terrell, Jr.
668. *Liparis loeslii* (L.) Rich. Fen Twayblade. Hocking Co. Chas. Goslin.
670. *Aplectrum hyemale* (Muhl.) Torr. Putty-root. Pike Co. Gordon S. Crowl.
673. *Corallorrhiza wisteriana* Conrad. Wister's Coral-root. Scioto Co. Clyde H. Jones.
678. *Magnolia acuminata* L. Cucumber Magnolia. Dellroy, Carroll Co. Clyde H. Jones.
679. *Liriodendron tulipifera* L. Tulip Tree. Athens Co. B. B. Bodle.
680. *Asimina triloba* (L.) Dunal. Papaw. Fairfield Co. Chas. R. Goslin.
681. *Ranunculus abortivus* L. Kidney-leaf Crowfoot. Athens, Athens Co. Warren Abbott.
682.1. *Ranunculus allegheniensis* Britt. Mountain Crowfoot. Union Twp., Morgan Co. W. P. Porter and P. S. Wamsley.
684. *Ranunculus recurvatus* Poir. Hooked Crowfoot. Highland Co. Katie M. Roads.
689. *Ranunculus septentrionalis* Poir. Swamp Buttercup. Loudenville, Ashland Co. Anonymous.
690. *Ranunculus hispidus* Mx. Hispid Buttercup. Tuscarawas Co. Don M. Brown. Buffalo Beat, Athens Co. F. Reemsnyder.
706. *Delphinium tricorne* Mx. Dwarf Larkspur. Athens, Athens Co., and Clear Creek, Hocking Co. Warren Abbott.
707. *Delphinium exaltatum* Ait. Tall Larkspur. Scioto Co. Clyde H. Jones.
713. *Anemone quinquefolia* L. Wind Flower. Tuscarawas Co. Irma Nelson.
715. *Hepatica acutiloba* DC. Sharp-lobed Liver-leaf. Pike Co. Gordon S. Crowl. Loudenville, Ashland Co. Anonymous.
717. *Clematis virginiana* L. Virginia Virgin's-bower. Pike Co. Gordon S. Crowl.
718. *Viorna viorna* (L.) Small. Leather-flower. Jeffersonville, Fayette Co. Mrs. F. C. Lampe.
722. *Actaea alba* (L.) Mill. White Baneberry. Wood Co. R. E. Shanks.
724. *Syndesmon thalictroides* (L.) Hoffmg. Rue-anemone. Wood Co. R. E. Shanks. Holmes Co. E. P. MacArthur. Athens Co. Warren Abbott.
726. *Thalictrum dasycarpum* Fisch. & Lall. Purplish Meadow-rue. Benton Twp., Hocking Co. Chas. R. Goslin.
728. *Thalictrum polygamum* Muhl. Tall Meadow-rue. Benton Twp., Hocking Co. Chas. R. Goslin.
729. *Thalictrum dioicum* L. Early Meadow-rue. Loudenville, Ashland Co. Anonymous. Holmes Co. E. P. MacArthur. Athens, Athens Co. Warren Abbott.
729.1. *Thalictrum adiantifolium* Hort. Maiden-hair Meadow-rue. Highland Co. Katie M. Roads. Escaped from cultivation.

735. *Caulophyllum thalictroides* (L.) Mx. Blue Cohosh. Marion Twp., Hocking Co. Chas. R. Goslin. Athens, Athens Co. Warren Abbott.
736. *Jeffersonia diphylla* (L.) Pers. Twinleaf. Pike Co. Gordon S. Crowl.
811. *Arabis canadensis* L. Sickle-pod Rock-cress. Red Hills, Franklin Co. L. E. Hicks.
821. *Cardamine pennsylvanica* Muhl. Pennsylvania Bitter-cress. Athens, Athens Co. Warren Abbott. Pike Co. Gordon S. Crowl.
824. *Dentaria diphylla* Mx. Two-leaf Toothwort. Geauga and Tuscarawas Co. Don M. Brown.
826. *Dentaria laciniata* Muhl. Cut-leaved Toothwort. Athens, Athens Co. Warren Abbott.
840. *Raphanus raphanistrum* L. Wild Radish. Berne Twp., Fairfield Co. Wm. and Robt. Goslin.
843. *Polanisia graveolans* Raf. Clammy-weed. Newark Twp., Licking Co. Warren Abbott. Buchtel, Athens Co. Leonard Stephenson.
848. *Geranium maculatum* L. Wild Crane's-bill. Athens, Athens Co. Warren Abbott. Richland Twp., Holmes Co. E. P. MacArthur.
856. *Oxalis grandis* Small. Great Wood-sorrel. Ashtabula, Ashtabula Co. L. E. Hicks.
858. *Oxalis cymosa* Small. Tall Wood-sorrel. Pike Co. Gordon S. Crowl. Wood Co. R. E. Shanks.
867. *Linum striatum* Walt. Ridged Flax. Fairfield Co. William Goslin.
882. *Polygala viridescens* L. Purple Milkwort. Geauga Co. E. P. MacArthur. Athens Co. F. Hall. Wood Co. R. E. Shanks.
886. *Polygala verticillata* L. Whorled Milkwort. Buckeye Lake, Licking Co. Warren Abbott. Ross Co. Gordon S. Crowl.
888. *Acalypha virginica* L. Virginia Three-seeded Mercury. Pike Co. Gordon S. Crowl.
889. *Acalypha gracilens* Gr. Slender Three-seeded Mercury. Ross Co. Gordon S. Crowl.
895. *Poinsettia dentata* (Mx.) Small. Toothed Spurge. Pike Co. Gordon S. Crowl.
901. *Tithymalus cyparissias* (L.) Hill. Cypress Spurge. Tillerman Bog, Greenville, Darke Co. Dale W. Jenkins.
905. *Tithymalopsis corollata* (L.) Kl. & Garcke. Flowering Spurge. Logan Co. A. G. Welshimer.
907. *Chamaesyce preslii* (Guss.) Arth. Nodding Spurge. Buckeye Lake, Licking Co. Warren Abbott. Pike Co. Gordon S. Crowl.
909. *Chamaesyce maculata* (L.) Small. Spotted Spurge. Green Twp., Scioto Co. F. B. Chapman and Conrad Roth.
918. *Malva moschata* L. Musk Mallow. Geauga Co. E. P. MacArthur.
923. *Sida spinosa* L. Prickly Sida. Berne Twp., Fairfield Co. Wm. Goslin. Pike Co. Gordon S. Crowl.
932. *Tilia americana* L. American Linden. Laurel Twp., Hocking Co. Chas. R. Goslin.
936. *Hypericum ascyron* L. Great St. John's-wort. Portage Co. E. P. MacArthur.
937. *Hypericum prolificum* L. Shrubby St. John's-wort. Ross Co. Gordon S. Crowl.
939. *Hypericum perforatum* L. Common St. John's-wort. Clay Twp., Perry Co. Chas. Reutinger.
940. *Hypericum punctatum* Lam. Spotted St. John's-wort. Pike Co. Gordon S. Crowl. Fairfield Co. Chas. R. Goslin.
950. *Triadenum virginicum* (L.) Raf. Marsh St. John's-wort. Stark Co. Don M. Brown. Logan Co. A. G. Welshimer.
965. *Viola pubescens* Ait. Hairy Yellow Violet. Ross Co. Gordon S. Crowl.
970. *Viola rostrata* Pursh. Long-spurred Violet. Pike Co. Gordon S. Crowl.
971.1. *Viola arvensis* Murr. European Field Pansy. Franklin Co. L. E. Hicks.
978. *Viola cucullata* Ait. Marsh Blue Violet. Clinton Twp., Wayne Co. E. P. MacArthur. Berne Twp., Fairfield Co. Chas. R. Goslin.
979.1. *Viola nephrophylla* Greene. Northern Bog Violet. Green Island, Ottawa Co. Alberta Doan.
983. *Viola triloba* Schw. Three-lobed Violet. Ross Co. Gordon S. Crowl.
988. *Viola sagittata* Ait. Arrow-leaf Violet. Tuscarawas Co. Don M. Brown.
994. *Arenaria serpyllifolia* L. Thyme-leaf Sandwort. Adams Co. Don M. Brown.
1004. *Alsine graminea* (L.) Britt. Lesser Stitchwort. Clinton Twp., Wayne Co. E. P. MacArthur.
1005. *Cerastium vulgatum* L. Common Mouse-ear Chickweed. Ross Co. Gordon S. Crowl.
1006. *Cerastium viscosum* L. Mouse-ear Chickweed. Adams Co. Katie M. Roads. Pike Co. Gordon S. Crowl.
1015. *Lychnis alba* Mill. White Lychnis. Logan Co. A. G. Welshimer.
1020. *Silene latifolia* (Mill.) Britt. & Rendle. Bladder Campion. Union Twp., Logan Co. A. G. Welshimer.
1023. *Silene noctiflora* L. Night-blooming Catchfly. Amanda Twp., Fairfield Co. Chas. R. Goslin.
1035. *Dianthus armeria* L. Deptford Pink. Ross Co. Gordon S. Crowl. Clinton Co., E. E. Terrell, Jr.
1038. *Claytonia virginica* L. Spring-beauty. Monroe Co. Clyde H. Jones. Pike Co. Gordon S. Crowl.

1048. *Anychia canadensis* (L.) B. S. P. Slender Anychia. Fairfield Co. William Goslin.
1054. *Amaranthus graecizans* L. Tumble-weed. Fairfield Co. William Goslin.
1080. *Steironema ciliatum* (L.) Raf. Fringed Yellow Loosestrife. Dellroy, Carroll Co. Clyde H. Jones. Pike Co. Gordon S. Crowl.
1100. *Rumex obtusifolius* L. Broadleaf Dock. Berne Twp., Fairfield Co. Chas. R. Goslin.
1105. *Tiniaria scandens* (L.) Small. Climbing False Buckwheat. Pike Co. Gordon S. Crowl.
1107. *Fagopyrum fagopyrum* (L.) Karst. Buckwheat. Ross Co. Gordon S. Crowl. Benton Twp., Hocking Co. Chas. R. Goslin.
1111. *Persicaria careyi* (Olney) Greene. Carey's Persicaria. Lucas Co. R. E. Shanks.
1112. *Persicaria persicaria* (L.) Small. Lady's Thumb. Pike Co. Gordon S. Crowl. Highland Co. Katie M. Roads.
1113. *Persicaria hydropiperoides* (Mx.) Small. Mild Smartweed. Stark Co. Don M. Brown.
1114. *Persicaria punctata* (Ell.) Small. Dotted Smartweed. Pike and Ross Co. Gordon S. Crowl.
1115. *Persicaria hydropiper* (L.) Opiz. Water Smartweed. Pike Co. Gordon S. Crowl.
1116. *Persicaria lapathifolia* (L.) S. F. Gr. Pale Persicaria. Highland Co. Katie M. Roads. Wood Co. R. E. Shanks.
1117. *Persicaria pennsylvanica* (L.) Small. Pennsylvania Persicaria. Pike Co. Gordon S. Crowl.
1118. *Persicaria muhlenbergii* (Wats.) Small. Swamp Persicaria. Highland Co. Katie M. Roads. Wood Co. R. E. Shanks.
1119. *Persicaria amphibia* (L.) S. F. Gr. Water Persicaria. Indian Lake, Logan Co. A. G. Welshimer.
1120. *Tovara virginiana* (L.) Raf. Virginia Knotweed. Ross Co. Gordon S. Crowl. Highland Co. Katie M. Roads. Wood Co. R. E. Shanks.
1126. *Saururus cernuus* L. Lizard's-tail. Adams Co. Don M. Brown.
1128. *Geum vernum* Raf. T. & G. Spring Avens. Highland Co. Katie M. Roads.
1131. *Geum flavum* (Porter) Bickn. Cream-colored Avens. Clinton Co. E. E. Terrell, Jr.
1132. *Geum strictum* Ait. Yellow Avens. Pike Co. Gordon S. Crowl. Tillerman Bog., Greenville, Darke Co. Dale W. Jenkins.
1135. *Potentilla monspeliensis* L. Rough Cinquefoil. Tillerman Bog, Greenville, Darke Co. Dale W. Jenkins.
1136. *Potentilla recta* L. Upright Cinquefoil. Belmont Co. Anonymous. Clinton Co. E. E. Terrell, Jr.
1138. *Potentilla canadensis* L. Common Five-finger. Laurel Twp., Hocking Co. Chas. R. Goslin.
1139. *Potentilla pumila* Poir. Dwarf Five-finger. Adams Co. Katie M. Roads. Pike Co. Gordon S. Crowl.
1144. *Waldsteinia fragarioides* (Mx.) Tratt. Dry Strawberry. Richland Twp., Holmes Co. E. P. MacArthur.
1145. *Fragaria virginiana* Duch. Virginia Strawberry. Adams Co. Katie M. Roads. Clinton Twp., Wayne Co. E. P. MacArthur.
1148. *Rubus odoratus* L. Rose-flowered Raspberry. Logan Co. A. G. Welshimer and Lee Pennock.
1160. *Porteranthus stipulatus* (Muhl.) Britton. American Ipecac. Goodhope Twp., Hocking Co. Chas. R. Goslin.
1166. *Spiraea tomentosa* L. Steeple-bush. Ross Co. Gordon S. Crowl.
1170. *Rosa setigera* Mx. Prairie Rose. Wood Co. R. E. Shanks. Ross Co. Don M. Brown.
1179. *Agrimonia parviflora* Sol. Small-flowered Agrimony. Highland Co. Katie M. Roads.
1180. *Agrimonia rostellata* Wallr. Woodland Agrimony. Highland Co. Katie M. Roads.
1186. *Prunus virginiana* L. Black Cherry. Pike Co. Gordon S. Crowl.
1188. *Prunus mahaleb* L. Mahaleb Cherry. Warren Co. Mrs. Herbert Cook.
1194. *Prunus americana* Marsh. Wild Plum. Wood Co. R. E. Shanks.
1197. *Sorbus scopulina* Greene. Western Mountain-ash. Franklin Co. Emma Ruppersburg (1897) Cultivated.
1281. *Meibomia rigida* (Ell.) Ktz. Rigid Tick-trefoil. Liberty Twp., Wood Co. and Henry Co. R. E. Shanks.
1283. *Meibomia obtusa* (Muhl.) Vail. Ciliate Tick-trefoil. Liberty Twp., Wood Co. R. E. Shanks.
1287. *Meibomia grandiflora* (Walt.) Ktz. Pointed-leaf Tick-trefoil. Pike Co. Gordon S. Crowl. Damascus Twp., Henry Co. R. E. Shanks.
1287.1. *Meibomia laevigata* (Nutt.) Ktz. Smooth Tick-trefoil. Pike Co. Gordon S. Crowl.
1288. *Meibomia nudiflora* (L.) Kuntze. Naked-flowered Tick-trefoil. Wood Co. R. E. Shanks.
1289. *Lespedeza hirta* (L.) Hornem. Hairy Bush-clover. Trumbull and Henry Co. R. E. Shanks.
1290. *Lespedeza capitata* Mx. Round-headed Bush-clover. Hocking Co. Don M. Brown.
1292. *Lespedeza violacea* (L.) Pers. Violet Bush-clover. Berne Twp., Fairfield Co. Chas. R. Goslin.

1294. *Lespedeza frutescens* (L.) Britton. Wand-like Bush-clover. Washington Twp., Henry Co. R. E. Shanks.
1295. *Lespedeza virginica* (L.) Britt. Slender Bush-clover. Newark, Licking Co. Eugene Good. Pike Co. Gordon S. Crowl.
1298. *Lespedeza striata* (Thunb.) H. & A. Japan Bush-clover. Pickaway Co. Chas. Schwim.
1299.1. *Stylosanthes riparia* Kearney. Decumbent Pencil-flower. Letart Falls, Meigs Co. D. R. Dodd.
1300. *Vicia cracca* L. Cow Vetch. Athens Co. Warren Abbott.
1301. *Vicia villosa* Roth. Winter Vetch. Clinton Co. E. E. Terrell, Jr.
1310. *Lathyrus palustris* L. Marsh Pea. Wood Co. R. E. Shanks.
1318. *Glycine apios* L. Groundnut. Wood and Henry Co. R. E. Shanks.
1319. *Falcata comosa* (L.) Kuntze. Hog-peanut. Henry and Wood Co. R. E. Shanks.
1328.1. *Sedum sarmentosum* Bunge. Clear Creek, Hocking Co. Clyde H. Jones.
1330. *Sedum ternatum* Mx. Wild Stonecrop. Morgan Co. Chas. R. Goslin.
1332. *Micranthes virginiensis* (Mx.) Small. Early Saxifrage. Laurel Twp., Hocking Co. Chas. R. Goslin. Holmes Co. E. P. MacArthur. Pike Co. Gordon S. Crowl.
1333. *Micranthes pennsylvanica* (L.) Haw. Pennsylvania Saxifrage. Goodhope Twp., Hocking Co. Chas. R. Goslin.
1336. *Heuchera americana* L. Common Alum-root. Clear-creek, Hocking Co. Clyde H. Jones. Holmes Co. E. P. MacArthur.
1338. *Mitella diphylla* L. Two-leaf Bishop's-cap. Mohican Forest, Ashland Co. James Stevenson. Pike Co. Gordon S. Crowl.
1346. *Lythrum alatum* Pursh. Wing-angled Loosestrife. Logan Co. A. G. Welshimer.
1348. *Parsonia petiolata* (L.) Rusby. Blue Waxweed. Pike Co. Gordon S. Crowl.
1350. *Dirca palustris* L. Leatherwood. Wood Co. R. E. Shanks.
1357. *Ceanothus americanus* L. Common New Jersey Tea. Logan Co. A. G. Welshimer.
1363. *Vitis vulpina* L. Riverside Grape. Portage and Ross Co. Don M. Brown.
1367. *Euonymus atropurpurea* Jacq. Wahoo. Fairfield Co. William Goslin.
1372. *Celastrus scandens* L. Waxwork. Fairfield Co. William Goslin.
1378. *Aesculus hippocastanum* L. Horse-chestnut. Fairfield Co. William Goslin.
1380. *Aesculus octandra* Marsh. Yellow Buckeye. Pickaway Co. Floyd Bartley and Leslie L. Pontius.
1383. *Acer spicatum* Lam. Mountain Maple. Belmont Co. Clyde H. Jones.
1385. *Acer rubrum* L. Red Maple. Pleasant Twp., Fairfield Co. Chas. R. Goslin. Highland Co. Katie M. Roads.
1394. *Cotinus cotinus* (L.) Sarg. European Smoketree. Franklin Co. Emma Ruppersburg. Cultivated.
1397. *Platanus occidentalis* L. Sycamore. Fairfield Co. William Goslin.
1399. *Ulmus thomasi* Sarg. Cork Elm. Ross Co. Gordon S. Crowl.
1401. *Celtis occidentalis* L. Common Hackberry. Scioto Co. Clyde H. Jones.
1403. *Morus rubra* L. Red Mulberry. Fairfield Co. William Goslin.
1406. *Toxylon pomiferum* Raf. Osage-orange. Fairfield Co. William Goslin.
1408. *Humulus lupulus* L. Common Hop. Pike Co. Gordon S. Crowl.
1410. *Urticastrum divaricatum* (L.) Ktz. Wood-nettle. Ross Co. Gordon S. Crowl.
1412. *Urtica gracilis* Ait. Slender Nettle. Hopewell Twp., Perry Co. Chas. Reutinger.
1414. *Pilea pumila* (L.) Gr. Clearweed. Fairfield Co. William Goslin.
1416. *Parietaria pennsylvanica* Muhl. Pennsylvania Pellitory. Madison Twp., Scioto Co. Conrad Roth and F. B. Chapman.
1417. *Fagus grandifolia* Ehrh. American Beech. Adams Co. Clyde H. Jones.
1418. *Castanea dentata* (Marsh.) Borkh. Chestnut. Richland Twp., Holmes Co. E. P. MacArthur.
1419. *Quercus muhlenbergii* Engelm. Chestnut Oak. Pike Co. Gordon S. Crowl.
1423. *Quercus alba* L. White Oak. Fairfield Co. William Goslin.
1425. *Quercus macrocarpa* Mx. Bur Oak. Adams Co. Clyde H. Jones.
1426. *Quercus imbricaria* Mx. Shingle Oak. Wood Co. R. E. Shanks.
1430. *Quercus velutina* Lam. Black Oak. Richland Twp., Holmes Co. E. P. MacArthur.
1431. *Quercus coccinea* Wang. Scarlet Oak. Pike Co. Gordon S. Crowl. Wood Co. R. E. Shanks. Berne Twp., Fairfield Co. Chas. R. Goslin.
1431.1. *Quercus coccinea* Muench. var. *tuberculata* Sarg. Rush Twp., Scioto Co. Conrad Roth.
1432. *Quercus rubra* L. Red Oak. Pike Co. Gordon S. Crowl. Fairfield Co. William Goslin.
1434. *Carpinus caroliniana* Walt. Blue-beech. Fairfield Co. Chas. Goslin.
1435. *Ostrya virginiana* (Mill.) Willd. Hop-hornbeam. Laurel Twp., Hocking Co. Chas. R. Goslin.
1439. *Betula nigra* L. River Birch. Adams Co. Clyde H. Jones.
1446. *Hicoria cordiformis* (Wang.) Britt. Bitternut (Hickory). Fairfield Co. William Goslin. Pike Co. Gordon S. Crowl.
1448. *Hicoria glabra* (Mill.) Britt. Pignut (Hickory). Hocking Co. William Goslin. Pike Co. Gordon S. Crowl.
1450. *Hicoria ovata* (Mill.) Britt. Shagbark Hickory. Fairfield Co. William Goslin.

1455.1. *Leitneria floridana* Chapm. Cultivated. Ralph McSherry Nursery, Montgomery Co. Delzie Demaree.
1459. *Populus candicans* Ait. Balm-of-Gilead. Berne Twp., Fairfield Co. Chas. R. Goslin.
1462. *Populus grandidentata* Mx. Largetooth Aspen. Berne Twp., Fairfield Co. Chas. R. Goslin.
1464. *Salix amygdaloides* Anders. Peachleaf Willow. Stark Co. Don M. Brown.
1465. *Salix nigra* Marsh. Black Willow. Portage Co. Don M. Brown.
1469. *Salix alba* L. White Willow. Stark Co. Don M. Brown. Highland Co. Katie M. Roads.
1472. *Salix interior* Rowlee. Sandbar Willow. Carrol, Stark and Ashland Co. Don M. Brown.
1473. *Salix glaucophylla* Bebb. Broadleaf Willow. Highland Co. Katie M. Roads.
1474. *Salix cordata* Muhl. Heartleaf Willow. Portage Co. Don M. Brown.
1484. *Opuntia opuntia* (L.) Karst. Common Prickly-pear. Pleasant Twp., Fairfield Co. Chas. R. Goslin.
1493. *Grossularia cynosbati* (L.) Mill. Prickly Gooseberry. Berne Twp., Fairfield Co. Chas. R. Goslin.
1499. *Ludwigia alternifolia* L. Seed-box. Tillerman Bog, Greenville, Darke Co. Dale W. Jenkins. Wood Co. R. E. Shanks. Pike Co. Gordon S. Crowl.
1504. *Epilobium coloratum* Muhl. Purple Willow-herb. Ross Co. Gordon S. Crowl.
1505. *Epilobium adenocaulon* Haussk. Northern Willow-herb. Crane Hollow, Hocking Co. Chas. R. Goslin. Wood Co. R. E. Shanks.
1506. *Oenothera biennis* L. Common Evening-primrose. Pike Co. Gordon S. Crowl.
1507. *Oenothera oakesiana* Robb. Oakes' Evening-primrose. Ross Co. Gordon S. Crowl.
1511. *Kneiffia linearis* (Mx.) Spach. Narrowleaf Sundrops. Ross Co. Gordon S. Crowl.
1513. *Kneiffia longipedicellata* Small. Long-pedicelled Sundrops. Vinton Co. A. G. Welshimer.
1516. *Gaura biennis* L. Biennial Gaura. Cuyahoga Co. E. P. MacArthur.
1517. *Circaea lutetiana* L. Common Enchanter's-nightshade. Lucas Co. R. E. Shanks.
1532. *Asarum canadense* L. Wild Ginger. Athens, Athens Co. Warren Abbott.
1536. *Comandra umbellata* (L.) Nutt. Bastard Toad-flax. Richland Twp., Holmes Co. E. P. MacArthur. Buchtel, Athens Co. Warren Abbott.
1540. *Azalea lutea* L. Flame Azalea. Adams Co. Clyde H. Jones.
1543. *Epigaea repens* L. Trailing Arbutus. Richland Twp., Holmes Co. E. P. MacArthur.
1551. *Pyrola elliptica* Nutt. Shinleaf Wintergreen. Mohican Forest, Ashland Co. James Stevenson.
1557. *Monotropa uniflora* L. Indian-pipe. Athens, Athens Co. Warren Abbott. Mohican Forest, Ashland Co. James Stevenson.
1609. *Hydrophyllum appendiculatum* Mx. Appendaged Waterleaf. Adams Co. Chas. R. Goslin.
1610. *Hydrophyllum canadense* L. Broadleaf Waterleaf. Clinton Co. E. E. Terrell, Jr.
1611. *Spigelia marylandica* L. Indian-pink. Franklin Co. L. E. Hicks. Cultivated.
1613. *Ligustrum vulgare* L. Common Privet. Henry Co. R. E. Shanks. Cultivated.
1617. *Fraxinus pennsylvanica* Marsh. Red Ash. Wood Co. R. E. Shanks.
1628. *Gentiana andrewsii* Griseb. Closed Gentian. Vinton Co. Chas. R. Goslin.
1631. *Frasera carolinensis* Walt. American Columbo. Clinton Co. E. E. Terrell, Jr.
1633. *Obolaria virginica* L. Pennywort. Ashtabula Co. L. E. Hicks.
1634. *Menyanthes trifoliata* L. Buckbean. Stark Co. Don M. Brown.
1635. *Vinca minor* L. Periwinkle. Ross Co. Don M. Brown.
1638. *Apocynum cannabinum* L. Indian Hemp. Athens Co. C. Leben.
1645. *Asclepias purpurascens* L. Purple Milkweed. Laurel Twp., Hocking Co. Chas. R. Goslin.
1646. *Asclepias incarnata* L. Swamp Milkweed. Pike Co. Gordon S. Crowl.
1647. *Asclepias pulchra* Ehrh. Hairy Milkweed. Loudenville, Ashland Co. From Ohio University Herbarium. Collector unknown. 1893.
1649. *Asclepias amplexicaulis* Sm. Bluntleaf Milkweed. Marion Co. Clyde H. Jones.
1650. *Asclepias variegata* L. White Milkweed. Hocking Twp., Fairfield Co. Clyde H. Jones. Highland Co. Katie M. Roads.
1651. *Asclepias exaltata* (L.) Muhl. Tall Milkweed. Geauga Co. Charles Dambach. Laurel Twp., Hocking Co. Chas. R. Goslin.
1655. *Gonolobus laevis* Mx. Sandvine. Athens, Athens Co. F. Reemsnyder.
1666.1. *Physalis subglabrata* Mack. & Bush. Smooth Ground Cherry. Licking Co. Warren Abbott.
1671. *Physalis heterophylla* Nees. Clammy Ground-cherry. Highland Co. Katie M. Roads.
1676. *Solanum carolinense* L. Horsenettle. Granville, Licking Co. Warren Abbott.
1681.2. *Solanum psuedo-capsicum* L. Jerusalem Cherry. Fremont, Sandusky Co. Rutherford P. Hayes. 1880.
1685. *Penstemon calycosus* Small. Calycose Beard-tongue. Ross Co. Gordon S. Crowl.
1687. *Penstemon pallidus* Small. Downy White Beard-tongue. Adams Co. E. E. Terrell, Jr.
1692. *Chelone glabra* L. Smooth Turtle-head. Logan Co. A. G. Welshimer. Wood Co. R. E. Shanks.

1694. *Scrophularia marylandica* L. Maryland Figwort. Wood Co. R. E. Shanks.
1697. *Mimulus ringens* L. Violet Monkey-flower. Henry Co. R. E. Shanks.
1700. *Gratiola virginiana* L. Round-fruited Hedge-hyssop. Wood Co. R. E. Shanks. Ross Co. Don M. Brown.
1702. *Ilysanthes dubia* (L.) Barnhart. Short-stalked False Pimpernel. Hillsboro, Highland Co. Katie M. Roads. Ross Co. Gordon S. Crowl.
1706. *Dasistoma macrophylla* (Nutt.) Raf. Mullen Foxglove. Adams Co. Don M. Brown.
1713. *Agalinis tenuifolia* (Vahl.) Raf. Slender Agalinis. Ross Co. Gordon S. Crowl.
1715. *Otophylla auriculata* (Mx.) Small. Auricled Otophylla. Adams Co. A. R. Harper, E. S. Thomas, and Gordon S. Crowl.
1720. *Veronica officinalis* L. Common Speedwell. Ross Co. Gordon S. Crowl.
1728. *Veronica arvensis* L. Field Speedwell. Ross Co. Gordon S. Crowl. Franklin Co. Don M. Brown.
1733. *Pedicularis lanceolata* Mx. Lanceleaf Lousewort. Portage Co. E. P. MacArthur.
1734. *Pedicularis canadensis* L. Wood Lousewort. Pike Co. Gordon S. Crowl. Athens, Athens Co. Warren Abbott.
1744. *Bignonia radicans* L. Trumpet-creeper. Pike Co. Gordon S. Crowl.
1762. *Dianthera americana* L. Water-willow. Pike Co. Gordon S. Crowl.
1767. *Lappula virginiana* (L.) Greene. Virginia Stickseed. Wood Co. R. E. Shanks.
1768. *Cynoglossum officinale* L. Hound's-tongue. Ridge Twp., Van Wert Co. M. B. Overholt.
1770. *Mertensia virginica* (L.) DC. Virginia Cowslip. Pike Co. Gordon S. Crowl.
1779. *Myosotis arvensis* (L.) Hill. Field Forget-me-not. Athens, Athens Co. Warren Abbott.
1790. *Verbena stricta* Vent. Hoary Vervain. Wood Co. R. E. Shanks.
1792. *Verbena canadensis* (L.) Britt. Large-flowered Verbena. Tillerman Bog, Greenville, Darke Co. Dale W. Jenkins.
1793. *Lippia lanceolata* Mx. Frog-fruit. Ross and Pike Co. Gordon S. Crowl. Canaan Twp., Athens Co. Warren Abbott.
1795. *Trichostema dichotomum* L. Blue-curls. Ross Co. Gordon S. Crowl.
1798. *Teucrium canadense* L. American Germander. Ottawa Co. Don M. Brown.
1799. *Teucrium occidentale* Gr. Hairy Germander. Tillerman Bog, Greenville, Darke Co. Dale W. Jenkins. Marion Co. Clyde H. Jones.
1801. *Scutellaria lateriflora* L. Mad-dog Skullcap. Ross Co. Gordon S. Crowl.
1802. *Scutellaria serrata* Andr. Showy Skullcap. Pike Co. Gordon S. Crowl.
1803. *Scutellaria incana* Muhl. Downy Skullcap. Pike Co. Gordon S. Crowl. Athens Co. Warren Abbott.
1805. *Scutellaria pilosa* Mx. Hairy Skullcap. Pike Co. Gordon S. Crowl.
1807. *Scutellaria parvula* Mx. Small Skullcap. Adams Co. Don M. Brown.
1809. *Scutellaria galericulata* L. Marsh Skullcap. Ottawa Co. Don M. Brown. Geauga Co. E. P. MacArthur.
1812. *Mentha spicata* L. Spearmint. Wood Co. R. E. Shanks. Ross Co. Gordon S. Crowl.
1813. *Mentha piperita* L. Peppermint. Wood Co. R. E. Shanks. Highland Co. Katie M. Roads.
1817. *Mentha alopecuroides* Hull. Woolly Mint. Buchtel, Athens Co. Leonard Stephenson.
1820. *Mentha canadensis* L. American Wild Mint. Pike Co. Gordon S. Crowl.
1821. *Lycopus americanus* Muhl. Cutleaf Water-hoarhound. Licking Co. Warren Abbott.
1823. *Lycopus virginicus* L. Virginia Water-hoarhound. Pike and Ross Co. Gordon S. Crowl.
1824. *Lycopus uniflorus* Mx. Northern Water-hoarhound. Stark Co. Don M. Brown.
1827. *Koellia virginiana* (L.) MacM. Virginia Mountain-mint. Logan Co. A. G. Welshimer. Licking Co. Warren Abbott.
1828. *Koellia flexuosa* (Walt.) MacM. Narrowleaf Mountain-mint. Geauga Co. E. P. MacArthur.
1829. *Koellia pilosa* (Nutt.) Britt. Hairy Mountain Mint. Adams Co. Don M. Brown.
1840. *Hedeoma pulegioides* (L.) Pers. American Pennyroyal. Eden Twp., Licking Co. Warren Abbott.
1842. *Agastache nepetoides* (L.) Ktz. Catnip Giant-hyssop. Henry Co. R. E. Shanks.
1843. *Agastache scrophulariaefolia* (Willd.) Ktz. Figwort Giant-hyssop. Ross Co. Gordon S. Crowl.
1849. *Dracocephalum virginianum* L. Virginia Dragon-head. Wood and Henry Co. R. E. Shanks.
1853. *Stachys aspera* Mx. Rough Hedge-nettle. Wood Co. R. E. Shanks.
1854. *Stachys cordata* Ridd. Cordate Hedge-nettle. Adams Co. Clyde H. Jones. Warren Co. E. E. Terrell, Jr.
1859. *Lamium purpureum* L. Red Henbit. Athens, Athens Co. Warren Abbott.
1864. *Monarda didyma* L. American Bee-balm. Athens, Athens Co. Warren Abbott.
1867. *Monarda fistulosa* L. Wild Bergamot. Wood Co. R. E. Shanks.
1868. *Monarda mollis* L. Canescent Wild Bergamot. Lucas and Wood Co. R. E. Shanks.
1870. *Blephilia hirsuta* (Pursh.) Torr. Hairy Blephilia. Geauga Co. E. P. MacArthur. Ashland Co. Anonymous. Dellroy, Carroll Co. Clyde H. Jones.

1872. *Salvia pitcheri* Torr. Wild Blue Sage. Columbus, Franklin Co. Jane Roller.
1877. *Phryma leptostachya* L. Lopseed. Ross Co. Gordon S. Crowl. Wood Co. R. E. Shanks.
1885. *Plantago virginica* L. Dwarf Plantain. Athens Co. W. P. Porter.
1890. *Panax quinquefolium* L. Common Ginseng. Highland Co. Katie M. Roads.
1895. *Sanicula gregaria* Bickn. Clustered Snakeroot. Pike Co. Gordon S. Crowl.
1897. *Sanicula canadensis* L. Short-styled Snakeroot. Pike Co. Gordon S. Crowl.
1898. *Sanicula trifoliata* Bickn. Large-fruited Snakeroot. Pike Co. Gordon S. Crowl.
1957. *Galium pilosum* Ait. Hairy Bedstraw. Ross Co. Gordon S. Crowl.
1960. *Galium aparine* L. Common Cleavers. Ross Co. Gordon S. Crowl.
1961. *Galium triflorum* Mx. Fragrant Bedstraw. Fairfield Co. Chas. R. Goslin.
1963. *Galium tinctorum* L. Stiff Marsh Bedstraw. Wood Co. R. E. Shanks.
1965. *Galium concinnum* Torr. and Gray. Shining Bedstraw. Hocking Co. Chas. R. Goslin.
1969. *Sambucus canadensis* L. Common Elderberry. Clay Twp., Perry Co. Chas. Reutinger.
1979. *Viburnum dentatum* L. Toothed Arrow-wood. Adams Co. Clyde H. Jones.
1982. *Viburnum prunifolium* L. Black Haw. Richland Twp., Holmes Co. E. P. MacArthur.
1984. *Triosteum angustifolium* L. Yellow Horse-gentian. Athens, Athens Co. Warren Abbott.
1985. *Triosteum aurantiacum* Bickn. Scarlet-fruited Horse-gentian. Laurel Twp., Hocking Co. Chas. R. Goslin.
1986. *Triosteum perfoliatum* L. Common Horse-gentian. Wood Co. R. E. Shanks.
1997. *Lonicera glaucescens* Rydb. Glaucescent Honeysuckle. Laurel Twp., Hocking Co. Chas. R. Goslin.
1999. *Lonicera sullivantii* Gr. Sullivant's Honeysuckle. Adams Co. Clyde H. Jones.
2003. *Valerianella chenopodifolia* (Pursh.) DC. Goosefoot Corn-salad. Clinton Twp., Wayne Co. E. P. MacArthur.
2004. *Valerianella radiata* (L.) Dufr. Beaked Corn-salad. Jefferson Twp., Logan Co. A. G. Welshimer.
2014. *Specularia perfoliata* (L.) A. DC. Venus'-looking-glass. Hopewell Twp., Perry Co. Chas. Reutinger.
2015. *Lobelia cardinalis* L. Cardinal Lobelia. Indian Isles, Logan Co. A. G. Welshimer.
2162. *Aster phlogifolius* Muhl. Thinleaf Purple Aster. Clinton Co. E. E. Terrell, Jr.
2164. *Aster laevis* L. Smooth Aster. Berne Twp., Fairfield Co. Robt. Goslin.
2173. *Aster paniculatus* Lam. Panicled Aster. Stark Co. Don M. Brown.
2179. *Erigeron philadelphicus* L. Philadelphia Fleabane. Ross Co. Gordon S. Crowl.
2182. *Leptilon canadense* (L.) Britt. Common Horseweed. Pike Co. Gordon S. Crowl.
2191. *Eupatorium sessilifolium* L. Upland Boneset. Highland Co. Katie M. Roads.
2194. *Eupatorium urticaefolium* Reich. White Snake-root. Pike Co. Gordon S. Crowl.
2198. *Kuhnia eupatorioides* L. False Boneset. Logan Co. Arthur Harper and A. G. Welshimer.
2206. *Vernonia missurica* Raf. Missouri Ironweed. Jersey Twp., Licking Co. A. E. Waller.
2208. *Elephantopus carolinianus* Willd. Carolina Elephant's-foot. Pike Co. Gordon S. Crowl.
2212. *Achillea millefolium* L. Common Milfoil. Athens, Athens Co. Warren Abbott.
2228. *Artemesia annua* L. Annual Wormwood. Ross Co. Gordon S. Crowl.
2231. *Senecio aureus* L. Golden Squaw-weed. Athens, Athens Co. Warren Abbott. Laurel Twp., Hocking Co. Chas. R. Goslin.
2232. *Senecio obovatus* Muhl. Roundleaf Squaw-weed. Stark Co. and Winesburg, Holmes Co. Don M. Brown. Pike Co. Gordon S. Crowl. Athens Co. Warren Abbott.
2233. *Senecio pauperculus* Mx. Balsam Squaw-weed. Athens, Athens Co. Warren Abbott.
2249. *Cirsium lanceolatum* (L.) Hill. Spear Thistle. Fairfield Co. Chas. R. Goslin.
2251. *Cirsium muticum* Mx. Swamp Thistle. Wood Co. R. E. Shanks. Ross Co. Gordon S. Crowl.
2254. *Onopordon acanthium* L. Scotch Thistle. Near Piatt Castle, Logan Co. A. G. Welshimer.
2258. *Centaurea vochinensis* Bernh. Tyrol Star-thistle. Jefferson Twp., Logan Co. Arthur Harper and A. G. Welshimer. Cuyahoga Co. E. P. MacArthur.
2262. *Cichorium intybus* L. Chicory. Fairfield Co. William Goslin.
2266. *Cynthia virginica* (L.) D. Don. Virginia Cynthia. Holmes Co. E. P. MacArthur.
2274. *Tragopogon porrifolius* L. Salsify. Tillerman Bog, Greenville, Darke Co. Dale W. Jenkins.
2276. *Hieracium paniculatum* L. Panicled Hawkweed. Wood Co. R. E. Shanks.
2277. *Hieracium gronovii* L. Gronovius' Hawkweed. Madison Twp., Scioto Co. F. B. Chapman and Conrad Roth.
2279. *Hieracium scabrum* Mx. Rough Hawkweed. Stark Co. Don M. Brown. Pike Co. Gordon S. Crowl.
2285. *Hieracium greenii* Port. and Britt. Green's Hawkweed. Pike Co. Gordon S. Crowl.
2293. *Nabulus serpentarium* (Pursh) Hook. Lion's-foot. Madison Twp., Fairfield Co. Chas. R. Goslin.
2299. *Sonchus asper* (L.) Hill. Spiny Sow-thistle. Harrison Co. Irma Nelson.
2300. *Lactuca villosa* Jacq. Hairy-veined Blue Lettuce. Fairfield Co. Chas. Goslin.
2303. *Lactuca hirsuta* Muhl. Hairy Lettuce. Ottawa Co. Don M. Brown.